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ACHARYYA RAY COMMEMORATION VOLUME

CALCUTTA 1932

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9, Panchanan Ghose Lane, Calcutta.**

SECRETARY'S NOTE

To be summoned to take up the duties of a secretary in the matter of organising and editing this publication as a fitting adjunct to Acharyya Sir Prafulla Chandra Ray's Septuagenary Celebrations is an honour too high for one who may scarcely have any other claim to it than being by accident a humble pupil of the venerable savant, who yields to none in his devotion to his teacher. The opportunity for service—a supreme chance of paying homage to my *Guru*—has been, however, a deciding factor in my case. The call was too compelling to be ignored. The regard and admiration which I have for my Professor and for his noble work in diffusing the knowledge and practice of science at once fill me with an inspiration and enthusiasm in my undertaking. The task has been by no means easy, and while I weigh against it my own limitations, my enthusiasm, however, turned the scale. The decision to publish a COMMEMORATION VOLUME was taken on the 1st March, 1932 and a Board of Editors was also appointed on that date. It was not till the 12th April following that the Editors came into grips with the difficulties of the undertaking. It was not an easy matter to get ready a publication of suitable contributions from distinguished men of letters and science within the time at our disposal. For a time it appeared to be very doubtful whether our project could materialise before the 11th December 1932, the day fixed for the Celebration of which it was intended to be an organic part.

As a result of the Secretary's constant correspondence and repeated reminders no less than seventyfour learned contributions were received in time. Freedom was given to the contributors as to the subject and size of their contributions. These, however, could not be grouped for want of time under different sections according to their subject-matter. They were printed as they came in. Another editorial difficulty was that the final proofs were not received as they were sent out to the respective writers.

This has made the order of the articles largely accidental and mechanical.

The Volume as it is, with all these defects and difficulties, will I trust, be found by the weight of its contents worthy of the distinguished Scientist to whom it is dedicated. The Board of Editors record their respectful appreciation of the ready co-operation they have received from so many learned men, both here and abroad. As Secretary to the Board I owe special acknowledgment to them for their ungrudging assistance and helpful suggestions. My thanks are also due to the Assistant Secretary for all his labours. The Printers and Block-makers, as also Mr. Haripada Ray, the artist deserve commendation for their respective services.

On behalf of the Board of Editors, as on my own, I now proceed to offer to Acharyya Sir Prafulla Chandra Ray this concrete manifestation of our united efforts as our humble tribute of love, respect, admiration and reverence which the great savant by his genius, personality and achievements kindles and inspires in us. Acharyya Ray's services to the cause of education, science and literature, his zeal for the well-being of students, his philanthropic and humanitarian activities, his devotion to the cause of social and economic uplift and industrial regeneration of our country are well-known to all. His simplicity of life and spirit of ascetic self-denial, his amazing capacity for work, his endearing manners, his unbounded sympathy and patriotism are irresistible charms which at once captivate our heart, and inasmuch as they are a source of inspiration to the present and future generations of his countrymen, lay a just claim to a fitting recognition.

My task now done, I shall treasure up my association with the ACHARYYA RAY COMMEMORATION VOLUME as one of the happiest events of my life which has afforded me an occasion to share in a common effort of paying homage to that gifted and high-souled savant.

50, Kailas Bose Street
Calcutta, Dec. 11, '32.

SATYA CHURN LAW

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COMMEMORATION VOLUME

FOREWORD

The task of inditing a Foreword to **Acharyya Ray Commemoration Volume** naturally devolves on the President of the Board of Editors, and as such, it is not without a sense of my limitations that I undertake this task, though at the same time I feel I cannot let this opportunity go without expressing my gratitude for the great honour conferred on me.

Acharyya Sir Prafulla Chandra Ray Kt., C.I.E., D.Sc., Ph.D., F.C.S. having, by the grace of God, completed his seventieth year, it was resolved at a representative meeting of his students, admirers and countrymen held on the 1st March 1932, "to take steps to celebrate his Septuagenary in a manner compatible with the measure of love, respect, admiration and reverence which the great savant, by his genius, personality and achievements, kindles and inspires in them". Of the programme of celebration settled at that meeting the publication of a Commemoration Volume was to form an integral part, and for that purpose a Board of Editors was constituted as follows :

Hirendra Nath Datta, M.A., B.L., Vedantaratna, *President.*
Meghnad Saha, D.Sc., F.R.S.
Jnan Chandra Ghosh, D.Sc.
Rajsekhar Bose, M.A., B.L.
Charu Chandra Bhattacharyya, M.A.
Satya Churn Law, M.A., B.L., Ph.D., *Secretary.*
Satyendra Nath Sen-Gupta, B.Sc., *Asst. Secretary.*

The Board decided to bring out a handsome volume dealing broadly among others with such subjects as science, literature, economics and industries, sociology, religion and philosophy, and for which contributions were invited in the following languages, viz., Bengali, English, Hindi and Sanskrit.

The response to the Board's appeal for help and co-operation from persons distinguished in public life and in the fields of science, philosophy, literature and art was very encouraging, and the fact that the contributions came from both far and near eloquently testifies to the love, esteem and reverence in which our ascetic savant "in simple Indian dress and wearing simpler manners" (I am borrowing Mahatma Gandhi's words) is universally held.

My first words must be those of cordial thanks to the several contributors for their generous and prompt response. While taking stock of the yield, rich and varied as it has been, the Board of Editors congratulate themselves that they have been able to gather in their garner a bumper harvest, which they venture to think is not wholly unworthy of the all-too-unconscious *Karmayogin,* with whose name this Commemoration Volume is associated.

The simple annals of Sir P. C. Ray's life are soon told. Born in 1861 in a small village in the Khulna District in a middle class Bengali family, he got his primary education in the village school; he was then brought by his father to Calcutta, where he matriculated from the Albert School in 1878, and having taken his admission into the Metropolitan Institution of Pandit Iswar Chunder Vidyasagar passed his F.A. Examination in 1880. In 1882, while still a B.A. student, he went to England, having been able to secure the Gilchrist Scholarship. Before he left India he had come in direct touch with two remarkable personalities, Keshab Chunder Sen and Surendranath Banerji. The fascinating spiritual fire of Keshab Chunder and the burning patriotism of Surendra nath made a deep and abiding impression on his mind, which he still carries as a part of his "Psyche."

Arrived in Scotland, Prafulla Chandra Ray (as he then was) joined the Edinburgh University, taking up the B.Sc. course and inhibiting for the time being his early partiality for history and literature, devoted himself to an intensive study of Physical Science, especially Chemistry under the inspiring guidance of Professors Tait and Brown. He took his B.Sc. degree at that University in 1885 and his Doctorate (D.Sc.) in 1887—also securing the Hope Prize, which enabled him to prolong his stay and research work in

Edinburgh. In 1888 he returned to India and in 1889 joined the Calcutta Presidency College as Professor of Chemistry—which chair he had filled with marked distinction until 1916.

May I here make vocal a personal complaint which I have cherished inwardly against Dr. P. C. Ray ever since my college days? Why did he linger in Scotland for two years and join the Presidency College only in 1889—just when I was timed to leave it—and thus deprive me of the proud privilege of being counted among his pupils? But vain regrets do not alter the past, howsoever they may influence the future.

By 1915, thanks to the munificence of Sir Taraknath Palit and Sir Rash Behari Ghose, the College of Science had been established by the University of Calcutta and in the natural course of things Dr. P. C. Ray was invited to take charge of its Chemical Department. He accepted this offer and has since been in responsible charge. He still works in his laboratory generally from 9 a.m. to 4 p.m. with an hour's interval for meal and rest and knows no other respite even on all holidays save the Summer Vacation. Thus Science still is and has been for the last 45 years or more his preoccupation. Not that Science is his only occupation. Far from it, he has been and still is engaging himself in many other useful pursuits—other nationbuilding work. But when all is said and done, Science is and remains his *Suo Rani*—"the favourite wife" of this inveterate bachelor. The Dewan of Mysore once rebuked him (in a friendly way) that he had been giving a portion of his time to *Khudder* and untouchability—especially the former, depriving Science of her just dues. As we know, Dr. Ray has abounding faith in "achieving Swaraj at the point of the Spindle"—a touching partiality which I, for one, am unable to share. What, however, was Dr. Ray's reply?—'A year is made up of 12 months and each month of so many days and each day of so many hours. What does it matter if I devote a fraction of my time to these other pursuits?' For a person possessed with his prodigious capacity for work—for one who pays unto each unforgiving minute of each hour its legitimate tribute—this attitude is not unreasonable: for he is one of those few who have mastered the

secret of *Yoga*, which has been rightly defined as 'skill in action'—the ability 'in the midst of the crowd, to keep with perfect sweetness the independence of solitude.'

It is not for me a mere layman to appraise Dr. Ray's achievements as a scientist or say about the contributions he has made to our stock of chemical knowledge. On this let his own original work and papers contributed to scientific journals abroad (and their numbers run into 3 figures) speak for themselves. But this I know as well as others that he is by universal consent regarded as occupying an honoured seat in the front rank of the world's great chemists. Sir W. G. Pope, the President of the Chemical Society when congratulating him on his well-merited knighthood spoke of his "unique work in connection with the development of chemical research in India."

Shakespeare "who saw life steadily and saw it whole" speaks of a man of genius (one of his own immortal creation) as not merely a wit himself but the cause of wit in others. By his genius and application Dr. Ray has not only been holding aloft the torch of Chemical Science in India but has been able to light the flame in kindred hearts. His laboratory has proved the nursery of the young chemists of our New India, and not a few of his pupils have achieved European reputation as chemical investigators and researchers of high merit. Mention may also be made of Dr. Ray's interest in Zoology and Biological Science, and his Zoological Primer published several years ago. He has kept up his interest in the subject as is witnessed by his several recent contributions to the bi-monthly Scientific Journal, *Prakriti*.

In this connection I may say a word about Dr. P. C. Ray's *quality* as a teacher. There is nothing of stand-offishness in his composition—which is not unoften the characteristic of the modern teachers, some of whom make it their business not to look their students in the face. He comes very close to the *Rishi-Gurus* of ancient India, whose relations with their *Shisyas* were of filial cordiality—who were true spiritual fathers to their pupils and inspired them with their own lofty ideals. Dr. Ray is and continues to be a student, a hoary-headed student—a student in the midst of

his students. Age hath not withered him: he loves to speak of himself as a *Chhatra,* which in fact he is. Naturally his students, both of the past and present, speak enthusiastically of him, and of their debt of deep gratitude to him.

I have already referred to Dr. P. C. Ray's *Karma-Shakti,* his wonderful "will to work." A splendid illustration of this is furnished by the Bengal Chemical and Pharmaceutical Works Ltd., an enterprise which, starting with the tiny capital of Rs. 800/- furnished by himself, has become the largest concern of its kind in India—with a capital of over 25 lakhs and with ramifying activities in several allied fields. But this by no means exhausts his industrial activity: and we find him inspiring and pioneering several other industries, all designed to foster the economic regeneration of India—e.g., the Bengal Pottery Works, the Calcutta Soap Works, the Bengal Canning and Condiment Works, the Bangiya Inland Steam Navigation Co., &c., &c. That is why his friend and life-long colleague, Sir J. C. Bose speaks of 'his dual capacity as path-finder (in the field of research) and originator of work of great utility.'

When speaking of his capacity for sustained work one loves to recall with pleasure and pride his unique services in connection with the Khulna famine of 1921 and the disasterous floods in North Bengal in 1922. The Scientist for the nonce transformed himself into an organiser of flood relief and became the life and soul of a stupendous organisation, which collected in a short time over seven lakhs of rupees and did splendid relief work. One also thinks of his "wander lust," which impels him inspite of his feeble physical frame to undertake journeys to all parts of the world—a self-imposed Odyssey of considerable dimensions (It is a sober fact that within the last few years he has covered more than 100,000 miles in and out of India). And when one recollects that this Odysseus is a chronic dyspeptic, afflicted with age-long insomnia, and that besides indulging in his Pilgrim's Progress he gives his attention at one and the same time to such widely divergent subjects as Chemistry, Industry, History, Antiquity, Literature, Social reform, Politics, Education, Swadeshi and *Khudder,* and maintains an active and intimate touch with numerous public Institu-

tions such as the Calcutta University, the National Council of Education, Bengal (of which he is the president), the Bangiya Sahitya Parisad (which has thrice elected him to fill its presidential chair), the Indian Institute of Science (where he sits on the governing body) and in addition presides over or assists numerous conferences and convocations—e.g., the Indian Science Congress, the all-Bengal Literary Conference, the Congress of European Universities, the Indian Social Conference, one is truly filled with wonder and realises how the soul, if it will, can dominate the body. As Dr. Ray has truly said of himself—"My appetite simply grows on what it feeds upon (what a triumph for vitalism !) and by a long course of progressive degeneration" (?) he has (as has facetiously expressed it) "by now become the property of anybody and everybody" and may I add of anything and everything.

I have spoken before of Dr. Ray's early penchant for history and literature, which he tried to suppress at Edinburgh. But what use? Nature will assert itself—*Prakritim Yanti Bhutani*—and suppression is of small avail. So we find him even before he left the shores of Scotland writing his booklet "India before and after the Mutiny" which Principal Sir William Muir characterised as "bearing marks of rare ability." This Cerberus has dogged his footsteps all through life and I am reliably informed that even now by way of sop to this creature he has to devote at least an hour every afternoon to the study of literature and history.

No cloud is without its silver lining. This study apart from anything else has, if I may say so without disrespect, saved our savant, from being turned into a pedant which he assuredly would have become if he had been exclusively devoted to Science. To it we also owe his monumental History of Hindu Chemistry (in two volumes)—a work of rare merit which occupied all his spare time, as he has himself told us, during 15 years or more and which is a monument of scientific as well as of historical and antiquarian research. To the same penchant we are beholden for books and pamphlets like "The Misuse of the Bengali Brain," "The Bread Problem," "Endeavour and Success," "Essays and Discourses" and numerous articles,

papers and speeches and addresses—some of them models of lucid expression and thoughtful exposition—and last, but not least his latest work 'Life and Experiences of a Bengali Chemist'—an eminently readable and factful book of reminiscences, full of interesting anecdotes with illuminating side-lights on men and things.

Mysterious truly are the workings of the "Unconscious'! Here is a man who eschews wealth on principle, whose temperament is abhorrant to acquisitiveness, who has never cared for wordly possessions and who rigidly follows, if man has ever followed, the Christian precept (which is also the precept of our own *Rishis*)—"Thou O man of God! fly these things (desire of money and its attendant evils): pursue justice, godliness, faith, charity, patience, meekness"—yet he lives laborious days to increase the wealth of the nation and insistently calls on his countrymen "lulled by the langour of the land of lotus" to gird up their loins to heap pence upon pence until they swell into pounds.

What, one may ask, is the secret of Sir P. C. Ray's widespread popularity among his countrymen? No doubt his great achievements in the field of chemical science and his countrywide services carry their appeal. Mahatma Gandhi has spoken of him as a great and good servant of India. Great he undoubtedly is. But goodness, from the Indian standpoint, is greater than greatness and Acharyya Ray is ever more good that he is great. And it is his *goodness*—his childlike simplicity, his suavity of manner, his ready accessibility, his unblemished purity, his unostentatious charity, his voluntary poverty, his plain living and high thinking, his enthusiasm and optimism, his innate spirit of self-denial, his incurable habit of always taking a back seat, his sweetness and light, his sturdy independence, his inflexible incorruptibility, his quiet reserve of strength, his "do or die" attitude towards life—in one word his *nobility* of nature which has made him the cherished idol of his people. Service and Sacrifice—these are his watchword and one rightly feels there is for them no higher example to emulate.

I cannot more fittingly conclude this Foreword than by quoting

the eloquent words which our Board's Secretary, Dr. Satya Churn Law used, when sending out his invitation for contributions to the present volume—which words I heartily endorse: "Acharyya Ray's services to the cause of education, science and literature, his zeal for the well-being of students, his philanthropy and humanitarian activities, his devotion to the cause of social and economic uplift and industrial regeneration of our country are well known to all. His simplicity of life and spirit of ascetic self-denial, his amazing capacity for work, his endearing and accessible manners, his unbounded sympathy and patriotism are irresistible charms which at once captivate our heart and in as much as they are a source of inspiration to the present and future generations of his countrymen, lay a just claim to a fitting recognition".

I also place on record my appreciation (which I feel sure is shared by all my colleagues) of the untiring labours of Dr. Law in connection with the work of the Editorial Board and of his generosity in shouldering expenses for the publication of this volume. At the same time I must not omit mentioning how deeply the Board are grateful to Mr. Satyendra Nath Sen-Gupta, our most unassuming and devoted friend and indefatigable Assistant Secretary, but for whose ungrudging services they feel they could have hardly achieved their object within the short time at their disposal.

Lastly I offer my sincere apologies on behalf of the Board of Editors to those friends, both here and abroad, to whom we may through oversight have missed sending the invitation to contribute to this Commemoration Volume.

CALCUTTA
Dec. 11, 1932.

HIRENDRA NATH DATTA

ওঁ

"Uttarayan"
Santiniketan. Bengal

আচার্য্য প্রফুল্লচন্দ্র রায়ের
সত্তর বৎসর বয়সের
জয়ন্তী উপলক্ষ্যে
কবির এই অভিনন্দন।

আমরা দুজনে সহযাত্রী।

কালের তরীতে আমরা প্রায় এক ঘাটে এসে পৌঁচেছি। কর্ম্মের ব্রতেও বিধাতা আমাদের কিছু মিল ঘটিয়েছেন।

আমি প্রফুল্লচন্দ্রকে তাঁর সেই আসনে অভিবাদন জানাই যে আসনে প্রতিষ্ঠিত থেকে তিনি তাঁর ছাত্রের চিত্তকে উদ্বোধিত করেছেন, — কেবলমাত্র তাকে জ্ঞান দেন নি, নিজেকে দিয়েছেন, যে দানের প্রভাবে সে নিজেকেই পেয়েছে।

বস্তুজগতে প্রচ্ছন্ন শক্তিকে উদ্ঘাটিত করেন বৈজ্ঞানিক, আচার্য্য প্রফুল্ল তার চেয়ে গভীরে প্রবেশ করেছেন, কত যুবকের মনোলোকে ব্যক্ত করেছেন তার গুহাহিত অনভিব্যক্ত দৃষ্টিশক্তি, বিচারশক্তি,

বেশী শক্তি। সংসারে জ্ঞানতপস্বী দুর্লভ নয়, কিন্তু মানুষের মনের মধ্যে চরিত্রের ক্রিয়াপ্রভাবে তাকে ক্রিয়াবান করতে পারেন এমন মনীষী সংসারে কদাচ দেখতে পাওয়া যায়।

উপনিষদে কথিত আছে, যিনি এক তিনি বললেন, আমি বহু হব। সৃষ্টির মূলে এই আত্মবিসর্জনের ইচ্ছা। আচার্য প্রফুল্লচন্দ্রের সৃষ্টিও সেই ইচ্ছার নিয়মে, তাঁর ছাত্রদের মধ্যে তিনি বহু হয়েছেন, নিজের চিত্তকে সঞ্জীবিত করেছেন বহু চিত্তের মধ্যে। নিজেকে অকৃপণভাবে সম্পূর্ণ দান না করলে এ কখনো সম্ভবপর হোত না। এই যে আত্মদানমূলক সৃষ্টিশক্তি এ দৈবীশক্তি। আচার্যের এই শক্তির মহিমা জরাগ্রস্ত হবেনা। তরুণের হৃদয়ে হৃদয়ে নবনবোন্মেষশালিনী বুদ্ধির মধ্য দিয়ে তা দূরকালে প্রসারিত হবে। দুঃসাধ্য অধ্যবসায়ে জয় করবে নব নব জ্ঞানের সম্পদ। আচার্য নিজের জয়কীর্তি নিজে স্থাপন করেছেন উদ্যমশীল জীবনের ক্ষেত্রে, পাথর দিয়ে নয়, প্রেম দিয়ে। আমরাও তাঁর জয়ধ্বনি করি।

রবীন্দ্রনাথ ঠাকুর

২২ অঘ্রাণ
১৯৩২

॥ प्रफुल्लप्रशस्तिः ॥

ज्ञानं तद्दुर्लभं लोके श्रेयसे भुवनस्य यत् ।
आचारो दुर्लभस्तत्र प्रचारस्तत्र दुर्लभः ॥ १ ॥

यस्मिन्नेतत्त्रयमपि सम्परिस्फुटमन्वहम् ।
स कस्यासि न वन्द्यस्त्वं तत्त्वां वन्दे समादरात् ॥ २ ॥

नैष्ठिकब्रह्मचर्येण धृतलोकहितव्रतः ।
मूर्तस्त्यागो न कस्य त्वं चित्तमत्राधितिष्ठसि ॥ ३ ॥

आचार्यान् परमाचार्य शिष्यांस्ते विश्वविश्रुतान् ।
दृष्ट्वा हर्षातिरेकेण कस्य चित्तं न नृत्यति ॥ ४ ॥

स त्वं शुभाय सर्वेषां जीवेह शरदां शतम् ।
जीवतु त्वां समाश्रित्य जन्मभूश्च चिरं तव ॥ ५ ॥

शान्तिनिकेतन-विश्वभारती
आश्विन-कृष्णा तृतीया
शक० १३५४

विधुशेखरस्य

Acharya Ray I had the privilege of knowing for the first time when Gokhale was his next-door neighbour in 1901 and I was undergoing tutelage under the latter. It was difficult to believe that the man in simple Indian dress and wearing simpler manners could possibly be the great scientist and professor he even then was. And it took my breath away when I heard that out of his princely salary he kept only a few rupees for himself and the rest he devoted to public uses and particularly for helping poor students. Thirty years have made no difference to the great and good servant of India. Acharya Ray has set us an example of ceaseless service, enthusiasm and optimism, of which we may well be proud.

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૨૫-5-'3૨

M K Gandhi

Sir P. C. Ray has produced a deep impression in his dual capacity as a pathfinder and originator of work of great utility. From the earliest days he exhibited a special faculty for carrying out original investigations of a high order. It is impossible at the present time for others to realise the numerous difficulties and obstacles that confronted him. But these were never able to stand in the way of reaching the goal he had set before him; on the contrary they served as a stimulus to awaken to the utmost his latent powers.

In his long and distinguished career as a scientific investigator, which happily is not over yet, he has not only made important contributions in advancement of science, but has also evoked the true spirit of research among his disciples, many of whom now occupy very prominent positions in the scientific world. Such an achievement in the lifetime of one man is indeed remarkable but Sir P. C. Ray has done a great deal more.

He was one of the first to realise the importance of Indian industries for the economic advancement of the country. With this object in view he risked the very little he possessed; and the venture started in this modest way has now grown into perhaps the most successful chemical industry in the whole of India. By his personal faith and enthusiasm he has succeeded in enlisting for this work the whole-hearted devotion of his collaborators.

His twofold achievement of a scientific investigator as well as the founder of an important industry in this country on up-to-date lines, has rightly entitled him to be regarded as a benefactor of his country.

How far these works are traceable to his extreme simplicity

of life and the innate spirit of self-denial is known to me as an intimate friend who has known him for nearly half a century. The self-discipline that he acquired in his earlier days of struggle, has been his greatest asset, enabling him to work ceaselessly inspite of his having a none too strong constitution. It is the strength arising from his innate belief in the future that has preserved in him the vitality and optimism of youth inspite of his age of three score years and ten.

Others have also profited by his self-denial. He has wanted little and kept even less for himself, the rest being given away freely to poor students and in charities. The association of plain living and high thinking is always very rare; in addition to these there is in Sir P. C. Ray the element of vigorous action which knows no rest. The combination of such qualities in a single individual is indeed rare in any country, and there can be no higher example for the young generation to emulate than the life of this great teacher.

J. C. Bose

অভিনন্দন

দেব !

শুক্তি মাঝে মুক্তা যথা খনি মাঝে মণি,
তেমনি আসিলে তুমি এ আঁধার দেশে।
দেবকী সাধনা সাধি কংস কারাগারে
পাইলা পুরুষোত্তম পুত্র নীলমণি—
তেমতি মা বঙ্গলক্ষ্মী তপো আচরিয়া
লভিলা দেবের বরে প্রফুল্ল রতনে!
জনম সে পল্লিকোলে—বিহগকূজিতা
স্নিগ্ধশ্যামা, ফুলময়ী, আড়ম্বরহীনা;
বিধি দিলা পুণ্য, কর্ম্ম ললাটে লিখিয়া;
উদাসী শঙ্কর শিব—রাজরাজেশ্বর
কুবের ভাণ্ডারী যার তবু সে ভিখারী—
সে শুধু পিশাচ ভূতে দিবে নব প্রাণ!
ষোড়শ মাতৃকা দিলা শুভ আশীর্ব্বাদ
অক্ষয় কবচ দিলা অলক্ষ্যে শিরসে;
অর্পিলা দেবর্ষি দল তপোবল যত,
বিশ্বের নমস্য বীর চির ব্রহ্মচারী;
বিজ্ঞানের সরস্বতী কহিলা হাসিয়া,
"আপনা সঁপিও বাছা! দেশের কল্যাণে।"
সপ্ততি বর্ষের তাই শুভ অনুষ্ঠান;
প্রফুল্লজয়ন্তী আজি বঙ্গমা'র কোলে!
বিশ্বের মঙ্গল কর্ম্মী আত্মত্যাগী যোগী,
দীনে দয়া, সেবাব্রতী, লোকহিতে রত,

ধনী, দীন, জ্ঞানী, মূর্খ সবারি বান্ধব ;
কি দিব তোমারে মোরা—পারি কিবা দিতে ?
আজি যে ফুটিছে ফুল কানন উজলি
তোমারে পূজিতে দেব ! তোমারে পূজিতে ।
আজি যে সমীর বহে মধুর হিল্লোলে
তব গুণ গাহি দেব ! তব গুণ গাহি ।
আজি যে গাহিছে পাখী মধুর কাকলী
তোমারি মহিমাগীতি দিগন্তে ছড়ায়ে ।
আজিকার রবিশশী যশোরাশি তব,
ঢালিছে বিশুভ্র পূত ভাস্বর কিরণে ।
কত দেশে কত পূজা দিলা ভক্তিভরে
কত অনুরক্ত ভক্ত গুণগ্রাহী তব ।
আজি তব দীনা মা'র অঞ্চলের নিধি !
লহ মাতৃহস্তে শুভ ধানদূর্ব্বাফুল ।
আমরা নগণ্য দীন যদিও জগতে
তথাপি গর্ব্বিত আজি তোমারি গৌরবে ।
দিন শুভময় বিধি আমাদেরি তরে
তোমারে আরোগ্য, আয়ু, মহতী শকতি ।
আকাশে নিনাদে শঙ্খ অমরনিচয়
প্রফুল্লজয়ন্তী আজি প্রফুল্লের জয় !
অনুরক্ত ভক্ত আমি প্রণমি চরণে,
এ সুদিন স্মরি যেন বাকী যা' জীবনে ।

প্রণতা—

শ্রীমানকুমারী বসু

The Future of Chemistry in India

By Henry E. Armstrong (London).

I am specially drawn to Sir Prafulla Chandra Ray and would join my tribute to those of his other friends, because of my interest in the unique combination of gifts in his intellectual character and my admiration of the work he has accomplished, as well as of the example he has set. Of distinguished literary parentage, his own early Engilsh training was literary in a way unknown even to Englishmen. He is, in fact, an illustration of what might happen to us if we were trained through intensive study of our own language which we seldom, if ever, are advisedly. As a youth, during a long period of illness, he was an ardent student of English classic writers but he heard both Prof. Elliott's university lectures on Physics and Prof. Pedler's on Chemistry before going to England, in 1882, when he came of age, as holder of a Gilchrist scholarship. His intention was to remain a literary student : foreseeing, however, that the future progress of India was bound up with the pursuit of scientific inquiry, he allowed himself to be gradually tempted away from literature and history, although he continued the study of economics and politics. He was six years a student in Edinburgh University, where he came under Profs. Tait and Crum Brown. I am not surprised that he was attached into Chemistry. Crum Brown personally was one of the most engaging men that it was possible to find and unquestionably the most philosophically minded chemist of modern times.

Not a few English chemists have had an early so-called classical training in Latin and Greek. I do not know of one who also had an English training such as Ray enjoyed. He writes a perfect English. What is striking in him is the completeness and breadth of his modern outlook, as opposed to the confined, purely classical,

retrograde outlook of so many English literary scholars; we may learn a valuable lesson from him in this respect. Despite his English training, he has remained absolutely oriental in habits and tastes and has always lived an ascetic life. Probably, his health has suffered not a little from too spare a diet: had our present knowledge been avaliable, he would scarcely have taken so little care of himself.

He adopted Chemistry as a career on his return to India. From 1889 onwards, as a Professor in the Presidency College, Calcutta, he was mainly engaged in abstract chemical inquiry work which has led to his being termed "Master of Nitrites", a description I myself applied to him years ago.

He is noteworthy among his countrymen, even among academic chemists generally, by reason of the remarkable practical ability he has shown in founding and directing the Bengal Chemical and Pharmaceutical Works. When I visited him in Calcutta, late in 1914, I was much struck by the simplicity of his living quarters, the shelves laden with English classics, Carlyle, Emerson and many more. I was still more impressed by what I saw in his most interesting chemical factory. All idea of his being but a dreamer at once vanished: obviously he had combined dreaming with practice in a most remarkable way. The arrangements were strikingly original. Whatever thought of his being narrow in his outlook one might have gained from his entire devotion to one very special theme in academic chemistry, his handling of his science in the works gave clearest proof of his wide outlook and general grasp.

Letters will out! Whilst ever the practical chemist, he has found time to write an outstanding *History of Hindu Chemistry*, a work of great erudition, involving fifteen years of profound study. In addition, he is an idealist: an unsparing social worker, his whole mind has been given to helping forward his countrymen's interests. Being what he is and where he is, the general sanity of his outlook has been most surprising. It is men such as he, of broad culture, highly imaginative but at the same time practical, that are needed for the public service of chemistry to-day, not mere academic research workers.

In type Sir Prafulla Ray is perhaps more like a Frenchman than an Englishman in his receptive habit of mind: the nearest comparison I can make is to contrast him with Berthelot, not only a many-sided chemist but also an agronomist, man of letters and politician. Let me say frankly, Ray is not great as a chemical specialist nor was Berthelot: he has been occupied in too many directions, too much kept aloof from the field of chemical discovery and its masters, to have lost himself in the contemplation of the maze of chemical experience to the extent necessary to be entirely overcome by the magic and immensity of its problems. None the less, he is the founder of the Indian Chemical School. He has realised the truth of the wonderful words Rudyard Kipling has put into the mouth of the Holy Mahub in *Kim*—"Education greatest blessing when of best sorts, otherwise no earthly use." In India, perhaps more than anywhere, in future success will depend more upon the observance of the policy they indicate than in any development of research upon the narrow lines of academic practice.

His chemical character may be said to have been formed at a restful period—just before undermining storms set in. His first English teacher, Pedler, had been simply brought up, on thoroughly practical, honest lines. Crum Brown, a great master of his art, will have exercised a more philosophic influence upon his mental development. The period was not yet when chemistry was to be expanded, not on strictly scientific principles but, in large part, on religious lines, as the worship of faiths and doctrinal practices rather than of verified, unassailable fact. Ray is, therefore, not the modern, speculative, uncritical chemist but a late comer in the good old school that would take nothing for granted.

I can in large measure recapture the influences that were at work in framing his outlook as a chemist, as I knew both his trainers intimately. Pedler came to the Royal College of Chemistry, where I was a student, in 1867, after spending two years in studying pharmacy. We were intimate friends to the end of his life, in 1918. Frankland set him the task of separating the two amyl alcohols in fusel oil, following Pasteur's directions; he was

to oxidise these to the two corresponding valeric acids so as to ascertain the special properties of the active acid. This was the first study of optically active compounds undertaken after Pasteur had specially directed attention to the phenomena of optical activity. The work was done in the basement laboratory at the Royal College of Chemistry, not at the Royal Institution, as Sir William Tilden states in his Obituary notice of Pedler. In evaporating down large bulks of liquid, he stank the place out. I have ever since 'smelt' Fusel Oil, Optical activity and Pedler together :—

"Smells are surer than sounds or sights
To make your heart strings crack—"

Van't Hoff did not become the advocate of the tetrahedral hypothesis in explanation of optical activity until 1875, two years after Pedler was appointed Professor in Calcutta. The Arnhenius electrolytic dissociation hypothesis had not attracted any great attention up to the time when Ray left Edinburgh. James Walker, who was his fellow student, had not yet visited Leipzig to be overcome by Ostwald. The two speculations which have most influenced modern opinion, up to the time when electronic considerations were introduced, were therefore brought under both Pedler's and Ray's notice from a distance, so did not influence either in any special way. Both may be said to have been rational conservatives.

Merely as a chemical student, I early became interested in India as the land of Indigo and a variety of other dyestuffs, also the land of the Poppy, at a time when we were only beginning to guess at the constitution of complex natural compounds. Early in the 70's, I came into touch with its snakes, as a considerable amount of cobra poison, collected by Sir Joseph Fayrer, was put into my hands by my friend Lauder Brunton, the physician. I did what little I could with it. Nothing alkaloidal was to be found and at that time we were in no way able to account for its virulence. A few years later, I was fortunate in obtaining, through Kew, directly from India, two new turpentines—from *Pinus khasya* and *Pinus longifolia.* The oil from *Pinus khasya* was of special

interest, as it proved to be the optical opposite of French Oil of Turpentine; it is now known to be almost entirely dextro-α-pinene, *Pinus khasya* may therefore be ranked high among conifers as setting the highest example of a pure life; that its French cousin should be left-handed is more than passing strange—the two trees deserve close comparative study.

When the City and Guilds of London College was established, at South Kensington in 1884, there was much talk of the Indian Civil Engineering College, at Cooper's Hill, near Windsor. My friend McLeod, who had been lecture assistant to Hofmann and then to Frankland, was Professor of Chemistry there. My engineering colleague, Prof. Unwin, came from there. Unfortunately, the College was soon closed down and our College, in a measure, took its place, as a school for men going out to India—(Sir) Alfred Chatterton and many others. In this way, I was more directly brought into touch with Indian life and could better appreciate its diversity. I made my first visit to India in 1914, on my return from the British Association meeting in Australia, via Java, Singapore and Ceylon. I had thus gained an insight into tropical agriculture— sugar cane, rice, palm, coffee, indigo, tea, rubber etc. Travelling up Ceylon, after visiting the marvellous ruins at *Anaradnapura,* I took train to Madras and thence to Calcutta; from there, I visited Pusa, as well as Darjeeling and the nearby Cinchona plantations and Quinine factory. My ambition had ever been to see the Himalaya—at last it was satisfied! My pilgrimage was made. For sheer, ineffable beauty, nothing I have seen in the world can compare with the distant mountain view from Darjeeling of majestic Kanchenjunga, attended on either side by a long range of snowy giants of only slightly lower magnitude, embanking the entire horizion—"the greatest and grandest mountain range in the world". A couple of days later, a little lower down, when visiting the Cinchona factory, I had an entrancing view of the mountain, shortly after sunrise, actually from my bed, looking out of the window. Ever since, I have thought of India in terms of Kanchenjunga. With such beauty in the background, there cannot for ever be strife in its shadow, though much suffering

may be inevitable. The future office of our science must be to minimise such suffering and to make the beauty of the mountains and of nature generally felt to the full. It is to this end, I believe, that chemistry will need be cultivated in India. No other science can so minister to the public weal.

It was my privilege to give several lectures to Prof. Ray's students in Calcutta. I dwelt, as I always must, on the need of studying method—*on the need of learning to use knowledge rather than to know*. The way of the world is rather to misuse knowledge, if not to wallow in ignorance. As yet we have little conception of the art that is to be— the art of using knowledge methodically, with logical purpose, to a calculated end; the art of comparative study. We are too much carried away by sentiment, by our feelings and desires— we rarely act with thought or recognise how great is our ignorance and how little right we often have to act upon what we are pleased to call our opinions. This is our great difficulty to-day, the difficulty with which all government is beset. The conditions under which we live— our social systems— are very complex: to unravel the complexities is more than difficult; few are competent to do so. 'In a broad sense', the great Ruskin remarks, 'nobody has a right to have opinions but only knowledges'. Still in the words of a common proverb—"it is human to err." We can only overcome this inborn tendency by making a right use of knoweldge—by the practice of scientific method. Modern progress, particularly in engineering, is the outcome of our systematic use of the method. We have yet to apply it to ourselves. The schools have not yet learnt to use it. When they do, they will meet with only limited success—just as they do in teaching subjects generally. The majority probably will never become scientific in outlook, but just hewers of wood and drawers of water, mere artificers. These have to be taught far more simply than the few who have the ability to master method: the few who can be artists. I have written so much on this subject, specially in my Essays on the Teaching of Scientific Method (Macmillan) that I need now say no more.

What is called Research has been grossly overdone in recent

years. The vain attempt has been made to superadd a course in research to the ordinary all but entirely didactic course : the degree by research has been made the fashion at our Universities. It has long since worn out its welcome. What is needed is to teach the spirit that is behind all true research work—the spirit of logical inquiry, whether by observation or experiment, throughout the entire course of school training. When children are allowed and trained at school from the beginning to see and think for themselves, some progress will be made; some uplift of the general intelligence will follow. I gather from Ray's own writings that the need for such training in India is specially marked, but he foresees the difficulty of imparting it.

A bad example has been set from our side—the themes given out for study have too often been trivial and of no future value. A far better training is to be obtained by careful study and repetition of classic work of the old masters than by executing set exercises, which merely involve mastering another example in proof of an established rule. The student's aim should be proficiency, not publication of something which counts for nothing when published.

My own feeling has always been that it would be to the advantage of an Indian School of Chemistry to work out its own salvation rather than resort to European training. This is already being done in advanced Physics—with remarkable success. The exercise of individual effort is far more likely to lead to advance and the development of originality than is submission to a teacher, however eminent. In chemistry specially practice alone maketh perfect. What chemists are most suffering from to-day is lack of serious purpose—lack of broad and fundamental knowledge through failure to study the ancient books of learning. Liebig's warning to Kekule, "that to be a chemist a man must ruin his health by study", true when he gave it, is more than true to-day. To be a chemist of worth a man must be everything else in some degree—botanist, geologist, physiologist, physicist and socialist.

As to subject matter, there will always be work to be done in connexion with industry. The great work of the future, however, specially in India, will be the development of agriculture

with the definite object in view of providing food of approved value, far higher in quality than that now produced. Only in recent years have we been able to set this before us as our object.

We have failed thus far, even in England, to place Agriculture upon a pedestal of the highest scientific endeavour. We have had no efficient College to this end. I can imagine no higher service to India than the establishment of such an institution. Only a potential Liebig will be able to bring it into being and supervise its operations. Twenty years hence, perhaps, such a leader may be forthcoming, if meanwhile a few men who feel that they have some call to such service, some biological feeling, will set themselves in training, disregarding academic traditions and forswearing all desire to advertise that they have knocked another spot off another atom or in some other way, of remote concern to the world, made themselves exceptional.

Competent chemists, they will carry on their studies, both in field and laboratory, in every possible and desirable direction, so as to secure a commanding knowledge of the problems of animal and plant life and of the soil. Only men so qualified, with ripened powers of imagination, will be competent to act as saviours of the people in the not distant future. The example Sir Prafulla Chandra Ray has set may well serve to encourage such an order into being. They will be the scientific missionaries of the future, sworn to social service alone.

When and if it be established, I suggest that the College be called *Kamet College*—in view of the many attempts made before the mountain was climbed and the arduous task undertaken at its final conquest. The Himalaya stand out—asking that real effort be made in the plains as well as upon their slopes. They will furnish the power, in due course, when it can be well used.

Light in the Prevention and Treatment of Disease

By N. R. Dhar (Allahabad).

In recent years our conception on the occurrence of disease has undergone a profound change. Thanks to the memorable researches of Pasteur, Koch, Lister and others, the germ theory of disease was well established in the end of the nineteenth century and every disease was attributed to some bacteria. Later on came the researches which established the fact that some diseases are caused by parasites or protozoa. In other words, till the end of the last century, it was generally believed that most diseases are caused either by some bacteria or parasite. The bacterial or parastic theory of disease was so much trusted that Metchnikoff spent the last few years of his life in search of the bacteria causing diabetes and he expressed the view, that there are many common features in diabetes and syphilis and that diabetes must be of bacterial origin.

The strong position of the bacterial theory of disease has been modified by the researches on vitamins. From experiments on birds and animals when fed with chemically pure fats, carbohydrates, proteins, and salts, it has been established by Hopkins, Funk, McCollum, Mendel and others that healthy life is impossible under these conditions and in order to maintain health some naturally occurring food materials must be added to the chemically pure fats, proteins, carbohydrates and salts. The great Dutch medical man Eijkman showed from his experiments on prisoners, when fed with polished rice, that beri-beri is caused in man from lack of some portion of naturally occurring food materials; in this case, it is the polishing of the rice which when added to the polished rice removes the disease—beri-beri. This was the first instance of a disease, which was definitely attributed

to lack of the right kind of food-stuff. Other researches followed, and now we have a group of diseases known as 'Deficiency diseases' caused by the absence of vitamins or very small amounts of substances associated with naturally occurring food materials. Beri-beri, rickets, osteomalacia, pellagra, and sprue belong to this class of deficiency disease and can be prevented or cured by the addition of the proper vitamins, which occur in food materials.

It was believed from a long time that rickets, which is now known as a deficiency disease and the occurrence of which leads to defective bone formation in children, can be treated with light. In this connection it is interesting to note that rickets is not common in poor tropical countries like China and India, although the food supply is inadequate from the vitamin and other points of view.

Dhar has emphasised, that, besides rickets other deficiency diseases like beri-beri, sprue, night blindness, pellagra, osteomalacia, etc., can be successfully treated with sunlight. Moreover metabolism diseases like diabetes, gout, pernicious anaemia and even cancer are amenable to light treatment.

So far we have been discussing the beneficial influence of light on deficiency and metabolism diseases. Now let us consider what the position is, regarding the influence of light on bacterial diseases. Finsen may be looked upon as a father of modern light therapy, in the treatment of bacterial diseases. He began his pioneering work in 1893 and achieved great success in the treatment of Lupus, a tubercular skin disease difficult to cure. Over 1100 out of 1200 cases greatly improved on light treatment.

The next important step in light therapy was taken in 1903 when Dr. Rollier established a sanatorium at Lysin in Switzerland for the treatment of tuberculosis by sunshine. Dr. Rollier's name is known throughout the world as the saviour of lives of thousands of people, who had been declared incurable due to tuberculosis of bones. Hence Dr. Rollier has been rightly named the 'high priest of the modern sun worshippers' by another great worker in the domain of actinotherapy, namely Dr. Gauvin. After visiting

Lysin, C. W. Saleeby wrote, 'Nowhere on earth have I seen or heard all of anything so beautiful, so significant, so hopeful as the application of heliotherapy under the charge of Dr. Rollier.'

Dr. Gauvin writes, 'It is ingrained in healthy mortals to love light. Even those of sedentary habits and are unfitted for an outdoor existence prefer well-lighted and cheerful surroundings to darkness and gloom. A child, before the age of reason, instinctively seeks the light and abhors darkness. Light and laughter synchronize—darkness and depression do likewise.' The animals have the same instinctive love for light. It is a matter of common knowledge that unless the sun is very hot, animals take rest rather in the sunshine than in the shade. 'Mirth is banished when darkness envelops us, our senses become deadened and dulled and sleep supervenes.'

The preventive and curative value of sunlight was known from time immemorial. Even Dr. Rollier himself says, 'The practice of sun-cure is as old as the earth.' In ancient India, sunlight was valued, and generally school classes were held in the open air under the shade of trees. Infants are still exposed to light after besmearing them with oil. Sunlight has many other uses in the treatment of disease and sun is adored as a god in India. Greece, Babylon, Egypt and other countries made use of the healing power of the sun. The sun has been worshipped as the source of both life and light in very early times. Light has been looked upon as the giver of health and happiness, as the power that defeats the dreaded darkness, closely associated with death and destruction.

It appears that the Aryans worshipped the Sun—the great Lord of all, and they gave the name Dyaus, from which the Latin 'deus' and the English 'deity' seem to be derived. The Persians were sun-worshippers, and the name of the Sun god in Persia is 'Mithra', in Egypt 'Rā', in Greece 'Helios' and in Rome 'Sol'. The famous temple at Heliopolis was the centre for sun-worship. Hippocrates (460-370 B.C.), the father of Medicine, Cornelius Celsus and Galen (130-200 A.D.) practised heliotherapy by covering the head and exposing the rest of the body to the sun.

Cicero has described the Solaria which the wealthy Roman citizens built at their country villas.

In Peru, the Incas have been considered as gods, being the children of the sun. Syphilis has been treated by them by light. In England the Druids deified the sun and Stone-henge was the centre of sun worship and sabbath is still Sunday. Unfortunately with the advent of Christianity all pagan practice and worship were discredited, and light treatment fell into disuse and there was no appreciable revival till the end of the last century. In Bolivia, the Chiriguanos Indians pray to the sun with the following words, 'Thou art born and disappearest every day, only to revive always young. Cause that it may be so with me.' Even at the present time, the Parsis worship fire, and Hindus regard light divine. Hence in two great religions light worship still plays an important part.

In England the importance of sunlight was overlooked at the beginning of industrial revolution with the first large use of coal for producing power. New towns sprang up and factories were quickly built and large amounts of coal were wastefully burnt, with the generation of considerable amount of smoke, which cuts off light. It is interesting to note that windows were taxed in England as late as 1851 when the taxes on windows were repealed, and even now walled up windows could be seen in industrial centres in England. In this connection, the following suggestive lines of Sir Oliver Lodge will be of interest, 'When the most efficient parts of light are excluded, the organisms, which flourish are of the lowest kind; and the higher organisms are apt to succumb to the ravages when unaided by the beneficial influence of sunlight.'

After Finsen, interest in light therapy was aroused again, in 1902, when two outstanding men of medicine—Bernhard (1902) and Rollier (1903) in Switzerland were drawn to the study and practical employment of heliotherapy.

Light therapy is the proved method of choice in some diseases and a most useful adjuvant in many others. For prophylactic purposes it has wide scope, that is receiving intensive study

by the medical profession. Apart from those diseases in which actinotherapy is specific without other treatment, it has an extraordinary tonic effect, both mental and physical. So that it stimulates the patient's whole power over the minor foci of disease. It has been very well demonstrated that actinotherapy has exceedingly valuable uses in the treatment of rickets, metabolism disorders, nervous conditions, diseases of the respiratory tract and it is now an established routine procedure in welfare clinics throughout the land in ante- and post natal cases, and for backward infants. In hospitals, actinotherapy is of material assistance in strengthening patients before operations and in shortening convalescence.

In more specialised fields actinotherapy gives excellent results in many diseases of particular organs :—the skin, eye, ear, nose, throat, and genito-urinary organs. Its value is proved in many forms of tuberculosis. In dental surgery local applications of actinotherapy or luminous heat are beneficial in treating sepsis and inflammation. Actinotherapy has been practised with several kinds of actinic light sources, e.g. Hanovia quartz mercury vapour lamp made in various forms. It is a powerful source, and efficient and economical and easy to operate. The Alpine sunlamp of the Hanovia Company is useful for ultraviolet light; 30% of the total energy output is in the ultraviolet. The Jesionek lamp is found useful in light clinics where group treatment can be adopted. The Kromayer lamp (water cooled) is designed for light treatment of small lesions and orificial conditions. For treating throat with actinic rays, Eidinow model lamp is suitable.

Ultraviolet light is used in general medicine, pediatrics, dermatology, dental surgery, gynaecology, ophthalmology, ottolaryngology, surgery and tuberculosis.

H. R. H. the Prince of Wales in his presidential address to the 1926 meeting of the British Association at Oxford summarised aptly the value of light in the treatment of disease and maintenance of good health in the following words :—'Closely linked with the discovery of vitamins has been the more recent development of knowledge concerning the need of sunlight for health, in man

and his fellow animals as in plants. We know now that crippling deformity appears in the growing child unless he receives his proper share of the vitalising rays of the sun, either directly or through the presence in natural foods of vitamins which these rays have produced. Sunlight or its artificial equivalent has some importance already in the treatment of disease; but a realisation of its significance for health has a much greater importance in preventive hygiene. There can surely be no plainer duty for a state charged with the health of an industrial civilisation than to promote with all its resources the search for such knowledge as this, as well as to provide for its application when obtained.'

The value of light in surgical practice, particularly in the operating threatre is being realised and the results of the pioneering work at the famous Necker Hospital of Paris is known all over the world.

When medicinal treatment alone has been disappointing in such diseases as Lupus, *Alopecia-areatea,* hayfever, rickets, spasmophilia, tetany, Parkinsonism following *Encephalitis lelthargica,* and in other diseases, light treatment is found to be efficacious.

Physicians have for ages empirically advocated convalescence in a sunny place, simply because it was observed that recuperation is rapid in sunshine. Dr. Rollier says, 'Owing to the paucity of our knowledge concerning the action of light on the human body, the development of the technique of heliotherapy was of necessity chiefly empirical.'

Dr. Rollier states that thousands of observation have proved that, in the case of children, the organism most deteriorated by tuberculosis can be radically transformed by sunbath if carefully administered and combined with airbath. He reports, "In case of infantile surgical tuberculosis one sees regularly a complete uplift of the general condition parallel with the progressive healing of the infected centres, whether osteous, articular, glandular, peritoneal, or cutaneous. Solar action on these centres is by no means superficial. I have nearly forty thousand radiographic negatives showing conclusively that there is no tubercular

lesion, however deep, which escapes the influence of solar rays. In numerous cases of infantile osteoarthritis showing advanced destruction, the power of radiation for the reconstruction and osseous recalcification may go so far as 'restitution and integrum.' The reconstitution of the skeleton is not confined to tuberculosis; it is frequent in all cases of rickets. Hess of New York and his collaborators, Pappenheimer and Unger have shown conclusively the increase of calcium and phosphorus in the blood under the influence of solar light."

According to Dr. Rollier, the pigmentation acquired by the leguments under the action of the sun, confers on them a progressive resistance to cold and heat. The pigments favour the healing of wounds by resisting the penetration of germs and make the skin relatively immune. Children with bronze skin generally have microbic skin diseases such as furuncles, acue, etc. The pigmentation is supposed to play a still more important role. Experience shows that the resistance of patients is nearly always in proportion to the degree of his pigmentation, which not only acts in protecting the skin against the two violent irritation of the ultraviolet rays but in regulating the heating action of the sun. It seems probable that pigments receive, furnish and activate the elements necessary for the metabolism of the hormones. Bloch has shown in the skin, Pincussen and Rothman in the blood and Biekel and Ischido in the marrow of the bones that pigmentation leads to an increase in the deep biological process of a fermentative and hormonal nature.

Light treatment also exerts a marked influence on the muscular system. By dilating the capillaries, the radiations draw the blood from the depths to the surface through the muscular layers and thus act as a system of massage. Dr. Rollier asserts that little ricketty bodies, after some months of sun-cure, become possessed of firm muscles, full and harmonious forms, and sometimes lines as pure as those of the young athletes of ancient Greece.

Light treatment, especially at high altitudes, leads to an increased activity of the lungs and increased heart action and general circulation. The number of corpuscles and the haemo-

globin content improve and the nutritive process in the body are activated by light. The abdominal organs are stimulated by sun-bath and appetite is increased and the digestive functions are improved. According to Dr. Rollier, sun treatment exerts a favourable action on the endocrine systems and internal secretions.

Observations of Sonne, Dorno, Levy and others show that by the absorption of radiations from the sun, the temperature of the tissues rises and at a depth of two to three cms., it may be three to five degrees (C) higher than the skin temperature.

Dr. Rollier has utilised sunlight in dressing wounds of tranmatisms of all kinds, in compound fractures, and in osteomyelitis, because the sunlight kills the infectious germs, encourages cellular activity and repairs the tissues. Light is supposed to be better than any other antiseptic and fulfils the conditions of an ideal dressing. According to Dr. Rollier in osteomyelitis, sunlight dressing has helped to fill up the large osseous cavities better and more rapidly than the usual methods.

Heliotherapy has been strongly recommended not only in the treatment of lupus, but in numerous other skin diseases, e.g., eczema, impetigo, acue, etc. Dr. Rollier has obtained favourable results with sunlight in infantile paralysis, Little's disease, anaemia of all kinds and general debility. Dr. Joubert states 'the sun cure balcony will become in the surgical services of to-morrow as capital a necessity as the laboratory or the radiological service.'

In this connection the following considered opinion of Dr. Rollier is of great interest, "Twenty one years' experience with more than ten thousand cases of surgical tuberculosis, under strict radiographic control, permits us to state that heliotherapy or methodical sun-cure, is the most efficacious means of treating the multiple manifestations of tuberculosis. The sun-cure in conjunction with the air-cure and practised preferably at an altitude is certainly the treatment par excellence for tuberculosis, because it places the organism in ideal conditions for self-defence. It stimulates the nutrition of all the tissues, increases the proportion of

red corpuscles in the blood, promotes metabolic changes and assists the functioning of all the organs.

"Without entering into the detail of the different tuberculous localisations curable by sun treatment (tuberculosis of the vertebral column or Pott's disease, tuberculosis of the hip or coxalgia, of the knee, foot, arm, glands or adenitis, of the peritoneum or peritonitis, of the skin or lupus, etc.), let us say that heliotherapy is the highest expression of orthopaedic and conservative surgery. By the practice of heliotherapy it is possible to avoid, in the great majority of cases, operations which often result in irreparable mutilation."

Discussing the efficacy of sunlight in the treatment of pulmonary tuberculosis Dr. Rollier states 'During the war, Swiss soldiers with pulmonary cases were entrusted to our care. We may state that, for this class of case, the sun is a precious auxiliary of the air cure as practised at an altitude. Heliotherapy can be started only when the patient has lost fever. Sunbaths have to be given with the greatest prudence, specially at the beginning. The exposure begins with the feet. It is only after several weeks' progressive practice that the insolation of the chest and back is permissible, and then only for a few minutes in the beginning. In summer, the cure should be taken in the morning, when the air is still fresh. Under the combined influence of air and sun, and thanks to the beneficial local and general action of the latter, the pulmonary lesions gradually become healed, expectoration diminishes and then ceases. It is an error to believe that patients suffering from blood spitting can derive no benefit from sunbath. We have proved the contrary in many cases. Among patients rationally managed, heliotherapy cannot cause accidents from congestion.'

Speaking of preventible diseases, King Edward VII used to say 'If preventible, why was it not prevented.' If light can cure diseases, it should be able to prevent diseases. It is now known that a judicious application of sunlight is one of the most prophylactic agents. As the tuberculosis germ is contracted during infancy, it is desirable that efforts should be made to prevent its

development. To do this, we should increase the child's own power of resistance. Dr. Rollier is of opinion that the best way of increasing the resistance of a child is to bring him in contact with pure air and sunshine. With this object in view Dr. Rollier started in 1910 a 'preventorium' at Cergnat, in the Ormonts valley for carrying out preventive sunlight treatment primarily intended for children suffering from tracheo-bronchial adenopathy. After a few weeks, sickly children having narrow hollow chests, weak limbs and atrophied muscles are wonderfully changed. The skin is bronzed, the anaemic pallor is replaced by a rosy complexion and the general health is improved. The percentage of haemoglobin in blood increases, the muscles become firm, breathing is deeper and X-ray examination reveals progressive healing of the tracheo-bronchial ganglions.

In the *Eighth Annual Report of the Scottish Board of Health,* it is stated that the clinical results of the ultraviolet irradiation have been quite numerous and important. The results achieved so far seem to justify the conclusion, that light treatment is taking a very important place in medical science.

E. H. and W. K. Russel in their "Ultraviolet radiation and actinotherapy' (1928) state, "The greatest field of usefulness for ultraviolet radiation lies in the prevention rather than in the cure of disease. It is, however, almost a specific remedy in such dissimilar conditions as rickets, surgical tuberculosis, *Alopecia areata,* spasmophilia and hayfever; and in a very large number of diseases it is a useful adjuvant, supplementing other necessary remedial measures."

These authors have treated not only different types of tuberculosis by light but they have also reported that beneficial results can be obtained with actinotherapy in the case of the following ailments:—Debility, diabetes mellitus, acidosis, gout, obesity, acute muscular rheumatism, lumbago, muscular torticollis, fibrositis, chronic rheumatism, rheumatoid arthritis, injuries to muscles, joints and ligaments, rickets, bone lesions, osteomyelitis, osteitis, deformans (Paget's disease), tetany, amenorrhoea, anaemia (secondary and pernicious), chlorosis,

leukaemia purpura, haemophilia, affections of the endocrine glands, hypothyroidism, increased blood pressure, diseases of the heart, angina pectoris, Raynaud's disease, diseases of the central nervous system, mental diseases, neurasthenia, chorea, epilepsy, paralysis agitans, eucephalitis lethargica, locomotor ataxia, anterior poliomyelitis, neuritis, neuralgia, sciatica, facial palsy, spasmodic torticollis, asthma, bronchitis, pulmonary conditions due to the action of poisonous gases, empyema, emphysema, laryngismus stridulus, different types of pneumonia, pleurisy, pleurodynia, whooping cough, dyspepsia, gastric ulcer, constipation, diarrhoea, functional disorders of the gastro-intestinal tract, abdominal adhesions, cirrhosis of liver, cholicystitis, jaundice, traemorrhoids, fistula, marasmus, pyloric spasms, tetanus, latent malaria, nephritis, cystitis, orchitis, epidymitis, prostatitis, urethritis, gonorrhoea, dysmenorrhoea, sterility, treatment of the menopause, menorrhagia, metrorrhagia, post partum haemorrhage, vulvitis, vaginitis, leucorrhoea, pelvic peritonitis, pyelitis, infantilism, impotence, skin diseases accompanied by anomalies of sensation, inflammatory lesions of the skin, inflammations of the surface epidermis, inflammation of the deep epidermis, local infective inflammaton of the chorium, syphilis, newgrowths, ulcers, rodent ulcers, wounds, skin grafts, eczema and other skin troubles, diseases of the eyelids, diseases of the conjunctiva, diseases of the throat, diseases of the cornea, diphtheria, diseases of the nose, ear, teeth and periodental membrane, etc.

Ultraviolet radiation is being used in the new monkey house and reptile house at the London Zoological gardens.

E. H. and W. K. Russel write, 'Captain Braithwaite of the West African Medical Service informs us that eczema, impetigo, furunclosis, lupus and psoriasis are unknown among the Nigerian Negroes, and that extensive wounds heal rapidly without sepsis; and as has already been noted Dr. Leuba of the Swiss army found that pigmented skins would not respond to vaccination until the skin had been actually cut through instead of being merely scarified as usual.'

Actinotherapy is now in use in many hospitals for the treat-

ment of mental disorders and light treatment is invaluable during pregnancy, when the increasing demand of the growing foetus disturbs the calcium metabolism of the mother.

How to Expose?

Always begin sunbath with the lower limbs, which are less sensitive. This course is also a means of testing the endurance of the patient which is a special necessity with invalids. One has to proceed by graduated stages, increasing the exposure a few minutes every day, first the feet, then the legs, the abdomen and the chest. The head should always remain covered with a white cotton sunhat. The rate of progression should be slowed down as the trunk is reached. After a lapse of a certain time which varies with the patient, the time of the year and the power of the sun, the body is pigmented and can remain safely in the sun several hours every day. In the lower altitudes the midday sun should be avoided.

Generally the air and sunbath should always cause a feeling of comfort. The sick people should feel braced and strengthened during and after the exposures to the sun, which should not be unduly prolonged. The person should have a sense of well being on exposure and after.

The sunbath so efficacious for sick people and those disposed to be ill cannot but be beneficial to those who are healthy and are keen on preserving health.

If general irradiation is intended it is advisable to begin by fractional exposures. A fresh part is exposed at each sitting and the previously treated portions are exposed for longer periods.

The beneficial effect produced by ultraviolet radiation can be greatly increased when certain drugs, dyes or vaccines are taken internally. The following preparations have been found to be effective in this direction :—thyroid, parathyroid, ovarian, testicular and liver extracts, vaccines, e.g., tuberculines, codliver oils (in rickets), chlorophyll, colloidal calcium, resorcin, quinine, iodine, arsenic in tuberculosis, gold preparations in lupus, lupus

erythematosus, laryngeal and pulmonary tuberculosis, calcium chloride (intravenous in abdominal tuberculosis), calcium lactate with thyroid extract in asthma and hayfever, stercoporphyrin, uroporphyrin, erythrosin, genetian violet and eosin (the last five substances are assumed to act as sensitisers).

The following heavy metal salts circulating in the blood in very small amounts augment the effect of ultraviolet light:—Iron (in anaemia), mercury (in syphilis), bismuth, copper (in surgical tuberculosis), argochrome (silver and methylene blue for intravenous injections in influenza and pneumonia) and gold (in laryngeal tuberculosis and septic processes).

Reactions in local treatment are increased by the external applications of the following substances:—Copper ointment (in lupus), silver nitrate, hydrogen peroxide, calcium sulphide, sodium chloride, eosin, brilliant green, crystal violet, genetian violet, fluorescein, cyanosin, methylene blue and acridine.

Sun as a Source of Light

Light therapy has been more successful in the high Alps than elsewhere, not only because of the large amount of radiation available, but also because the snow absorbs heat rays and reflects ultraviolet rays.

Recent measurements of Coblentz show a marked increase in the ultraviolet rays with altitude. The amount of radiations of wave lengths 1700 to 4500 A at Washington (35 ft. above sea level) corresponds to 0·13 grm calorie, whilst it is 0·2 grm calorie at Flagstaff Ariz at an altitude of 7,000 ft. The solar radiation intensity falling on a surface normal to the incident rays at Washington at noon on a clear day amounts to about 1 grm. calorie/cm^2 per minute and rarely rises to 1·2 grm. calorie as compared with 1·6 grm. calorie at Flagstaff.

On a clear day, the amount of total radiation at 6000 ft. is roughly one and half times that reaching the earth at sea level. Owing to absorption by the earth's atmosphere at sea level, no radiations of wavelengths shorter than about 2,900 A reach the earth, similarly owing to the opacity of the earth's atmosphere, very

little infra-red radiations of wavelengths longer than 30,000 A are received from the sun.

It is not always necessary to expose a patient to direct sunlight, as there is a sufficient amount of indirect ultraviolet radiation in the diffused light of the blue sky.

Artificial light has also been used in light therapy. Some times the *gas-filled-tungsten lamp* has been used in light therapy as a light source. The ultraviolet radiation emitted from the gas-filled tungsten lamp is extremely small. The visible radiation from this lamp is only 3 to 4 per cent of the total radiation emitted. The bulb made of clear glass absorbs practically all radiations of wavelengths longer than 30,000 A. Coblentz states, 'That the spectral component of the radiations extending from 6,000 A in the red to 14,000 A in the infra red amounting to 30 % of the total radiation emitted, can penetrate deeply into the skin and hence can be effective therapeutically.'

The quartz-mercury-vapour lamp is convenient in studying the influence of ultraviolet rays on the body in general treatment. The majority of workers in actinotherapy seem to believe that ultravolet light plays the chief role in heliotherapy, although Dr. Rollier never emphasises the importance of ultraviolet rays. However, the application of mercury vapour lamps is daily increasing in light therapy. Recent years have witnessed great expansion in light therapy and at present the provision of lamps and accessories has become quite an industry. Two types of lamps are in use for the treatment of diseases; the air-cooled "sun-lamp" for general application or for the treatment of large areas and the water-cooled lamps for local applications. The air-cooled lamps seem to be adapted to yield a radiation containing larger proportion of rays of wavelength exceeding 3,000 A; whilst the water-cooled lamp is designed to give out an intense radiation, much of the energy of which is in the form of rays of wavelength less than 3,000 A.

The radiation from the quartz mercury arc lamp is distributed in a few intense emission lines. About 6% of the total radiation emitted is of wavelengths shorter than 2,900 A,which are practi-

cally absent in the solar rays received by the earth. These short rays have high germicidal action. According to Coblentz, apart from strong lines in the region 10,000 to 12,000 A, the mercury lamp emits very little infra-red light. The large amount of infra red radiations from the Cooper-Hewitt mercury lamp emanates from the incandescent tungsten anode and specially from the quartz enclosure.

The carbon arcs are valuable in the treatment of deep-seated tuberculosis, asthma and rheumatism and for prophylaxis. Adults can be best treated with these lamps. The mercury vapour lamps are very useful in the treatment of rickets, spasmophilia and tetany. Children can be conveniently treated with these lamps.

To secure more effective action of the radiations optical sensitisers are applied on the surface to be irradiated. These sensitisers may be dilute solutions of eosin or some other dye or calcium chloride solution.

Regarding the comparative influence of light on different individuals, Pacini (Outlines of ultraviolet-therapy, Chicago, 1923) writes, 'Speaking generally light people respond more promptly than dark, females than males, the younger sooner than the old, and the regions usually protected from the light and persons of higher nervous sensibility.'

Ellis and Wells [Chemical Action of ultraviolet Rays, p. 297, (1925)] state, 'To ascertain the effect upon the skin, eyes and general condition, Bach resorted to a heroic test. He applied the ultraviolet light with great intensity upon his own person without protecting his eyes. An exposure of 30 minutes was given at a distance of 16-20 inches from a 3,000 candle power lamp. The head and body were treated alternately. After 3 minutes, there was a sensation of warmth and after 10 minutes, a burning sensation at the place of exposure. An intense reddening appeared in two or three hours after the treatment. This discolouration disappeared in 3 days. There was no blistering but the epidermis became hard and dry, and peeled within a week, being replaced by a new epidermis, which was elastic and brown. The conjunctive commenced to redden in about two hours after treatment, being

inflamed and painful but the inflammation disappeared in about 3 days without treatment; immediately after treatment and for days thereafter, there was a feeling of freshness and increased energy. The effect perhaps may be expressed as a case of over stimulation of a person in good health.'

According to Sir Leonard Hill [Proc. Roy. Soc. B.**102**, 119, (1927)] sunlight focussed on the skin through a solution of 3% quinine sulphate, which absorbs rays of the mercury vapour lamp shorter than 4,200 A, does not produce erythema (sunburn), if the skin is kept cool by running water. The rays effective in producing erythema seem to lie in the ultraviolet. From rough experiments, Hill concluded that erythema producing rays of the sun lie mainly between 3,300-3,000A. There also appears to be a correspondence between the acetone methylene blue fading and erythema producing power of the sun's rays. The experiments of Hanssen and Vahle [Strahlen therapie Vol. 13, p. 59, (1922)] seem to be more precise. Using the mercury vapour lamp radiations of equal intensities as measured by a thermopile, they have found the maximum erythema production to be at 2967 A. At 3,131 A the erythema production was only 4·5% of that at 2,967 A while the erythema producing of rays of wavelength 3,131 A is relatively weak, the intensity of sunlight in this region is sufficient to be effective. The rays of the sun which exert an antirachitic effect and which can synthesise vitamin D from ergesterol lie between 3,200-2,700 A.

The short rays are absorbed by the thinnest layer of the epidermis and hence cannot penetrate deep into the body. According to Coblentz the longer rays, 4,000 to 14,000 A, have a greater penetration. On the other hand, rays of still greater wavelength cannot penetrate deeply in the blood stream. The following quantitative measurements by Glitscher and Hasselbach (Brit. J. Actinotherapy I September 1926) are of importance in explaining the part played by light in the treatment of disease :—

Transmission by epidermis.

Wavelength in A	Percentage transmission by 0·1 mm. thickness	1 mm. thickness
4360	59	0·5
4050	55	0·3
3660	49	0·08
3540	42	0·02
3130	30	...
3015	8	...
2990	2	...
2970	0·01	...

What is the fundamental action of light in heliotherapy?—In a recent communication Coblentz states:—"The action of these light rays on the blood stream is probably very complex. Part of the action is probably photochemical. But the supposition that the action of the light on one part of the body produces a fluorescence in the blood stream, which is carried to or produces a fluorescence deep within an illuminated part of the body seems untenable, because fluorescence is a phenomenon that occurs only at the point where and only so long as the object is irradiated; and it ceases the moment the light stimulus is shut off. Hence if a fluorescent substance which is introduced into the blood stream has a therapeutic effect, it is more likely owing to some photochemical change in the material rather than owing to the fluorescent property of the material. Some other non-fluorescent material might produce the same effect, either by undergoing a photochemical change in combination with the material in the blood stream or by some catalytic action on the white blood corpuscles.

"It seems quite possible for ultraviolet rays to produce fluorescence in the blood stream, say, in the white blood corpuscles, at the point where the ray impinge on the body. But this fluorescence would cease immediately after the corpuscles passed from under the spot irradiated. Hence, it is more likely that the ultraviolet rays stimulate the white corpuscles to greater activity, which continues as they travel deeper into the body.

"While these short ultraviolet rays are destructive to protoplasm, it has been observed that when the destructive action has not been carried too far, there is a stimulation of the cell. The

nature of this stimulation is a problem of physiology rather than of physics. It is physically impossible to introduce light deeply into the unilluminated blood stream by fluorescence and that an explanation of the observed therapeutic action of the ultraviolet rays is to be sought on some other basis.

"In concluding this discussion, it is relevant to call attention to the fact that differences in therapeutic action of sunlight and of the white flame carbon arc light, which closely resembles sunlight, may arise from differences in temperature conditions surrounding the body."

Oxidation of carbohydrates, fats and nitrogenous substances by air in sunlight:—It has been shown by Dhar and Sanyal [J. Phys. Chem. **29**, 926, (1925)] that methyl alcohol, ethyl alcohol and glycerol are oxidized simply by passing air at the ordinary temperature in presence of sunlight.

Palit and Dhar [J. Phys. Chem. **32**, 1263, (1928); **34**, 993, (1930)] have made a systematic investigation of the oxidation of various substances by air in sunlight at the ordinary temperature. They have shown that different carbohydrates, glycogen, urea, glycine, hippuric acid, α-alanine, sodium urate, potassium palmitate, stearate, oleate, sodium formate, tartrate, oxalate, lecithin, cholesterol, butter, milk, egg white, egg yellow, etc., can be oxidized at the ordinary temperature by passing air through aqueous solutions or suspensions of the above substances in presence of sunlight. Some experimental results are recorded below:—

Substance used in experiment.	Weight of substance taken.	Amount oxidized.	Percentage Amount oxidized.
Arabinose	0·1000 grm.	0·0075 grm.	7·5
Galactose	0·0861 ,,	0·0067 ,,	7·8
Cane sugar	0·0964 ,,	0·0098 ,,	10·2
Glucose	0·0962 ,,	0·0144 ,,	14·9
Laevulose	0·0918 ,,	0·0159 ,,	17·3
Lactose	0·0977 ,,	0·0197 ,,	19·7
Maltose	0·1097 ,,	0·0285 ,,	25·9
Starch	0·1027 ,,	0·0399 ,,	38·8

Substance used in experiment.	Weight of substance taken.	Amount oxidized.	Percentage Amount oxidized.
Glycogen	0·0987 grm.	0·0195 grm.	19·7
Glycerol	0·2500 ,,	0·0450 ,,	18·0
Urea	0·2000 ,,	0·0175 ,,	8·7
Glycine	0·0999 ,,	0·0096 ,,	9·6
α-alanine	0·0997 ,,	0·0365 ,,	36·6
Hippuric acid	0·0483 ,,	0·0069 ,,	14·2
Sodium urate	0·0420 ,,	0·0082 ,,	19·6
Potassium stearate	...	...	40
,, oleate	...	...	31·5
,, palmitate	...	...	36·7
,, oxalate	...	...	29·8
Sodium formate	0·0737 ,,	0·01467 ,,	19·8
,, tartrate	0·0989 ,,	0·0679 ,,	31·3

Moreover, it has been shown that in the presence of zinc oxide, ferric and uranium nitrates, which act as photo-sensitisers, the amount of oxidation of the foregoing substances is greatly accelerated. All the above substances are completely oxidized to carbon dioxide and water, wthout the formation of intermediate products.

Palit and Dhar have also carried on comparative experiments on the oxidation of egg white, egg yellow, starch, butter, glucose, cane sugar, and glycogen in sunlight and the following are the results :—

Substance	Percentage oxidized
Egg yellow	60·9 %
Egg white	31·25%
Starch	38·20%
Butter	31·80%
Glucose	13·60%
Cane sugar	7·80%
Glycogen	7·00%

It appears, therefore, that egg yellow is the most easily oxidizable substance in presence of light. Butter is more easily oxidized in light than the sugars, which appear to be the least oxidized. These experiments are close imitations of the biological oxidations. A similar order regarding ease of oxidation in the

animal body was observed by Carl von Voit, the great physiologist, from feeding experiments. These results on the oxidation of food materials by air in sunlight at the ordinary temperature are suggestive and the beneficial influence of light in the treatment of disease may be due to an increased metabolism in light. From these researches on the photo-oxidation of food materials by air in sunlight at the ordinary temperature, Dhar and Palit have concluded that the light absorbed by the animal body accelerates the metabolism of materials in the system. The person has a sense of well being when exposed to light as the metabolism is increased and hence light acts as a preventive and disease is avoided in presence of light.

It has already been emphasised that sunlight is appreciably transmitted by the epidermis and by the absorption of light the body cells are activated and the oxidation of the carbohydrates, fats, and proteins inside the animal body is accelerated. The increase in the metabolism of the food materials due to their increased oxidation by the oxygen respired aided by the radiations, which penetrate the body, is perhaps the most fundamental action of light which leads to the prevention and cure of disease when a person is exposed to light.

Dhar [Chemie. der Zelle. und Gewebe **12**, 217, 225, 317, (1925); **13**, 209, (1926)] has emphasised that the deficiency diseases like beri-beri, pellagra, sprue, rickets, etc., begin with stomachic troubles. Moreover, with pernicious anaemia, cancer, etc., the same symptoms are also observed. Diabetes is associated with defective metabolism of glucose, which mainly passes out unchanged from the body of the person suffering from diabetes. Gout is supposed to be caused by defective metabolism of proteins. The researches of Palit and Dhar have shown that carbohydrates, fats and proteins are readily oxidized by air in presence of sunlight. The light absorbed by the animal body accelerates the oxidation of carbohydrates, fats and proteins and hence, diseases like beri-beri, pellagra, sprue, rickets, cancer, pernicious anaemia, diabetes, gout, osteomalacia, etc., which originate with defective metabolism of food materials should be prevented or cured by light treatment.

Dhar has emphasised the importance of sunlight in the treatment and prevention of metabolism diseases and it seems likely that rickets, osteomalacia, beri-beri, pellagra, sprue, diabetes, gout, pernicious anaemia, cancer would have been more prevalent in poor tropical countries like India and China where the food materials lack in vitamins and good quality proteins and are also defective from other viewpoints, had not the compensating agent sunlight been present.

In this connection, the following observation of Dr. Bernhard of St. Moritz, Switzerland will be of interest :—"I have never seen carcinoma of the skin, of the face or hands in our roadmakers, roadrepairers, postillions or post conductors on the Alpine passes, who are exposed to every inclemency of the weather, and in winter months, to the most intense solar radiation, with its reflection from snow and ice which in spring gives them the appearance of bronze figures. I believe, on the contrary, that they are, if anything, more proof against carcinoma. In Negroes carcinoma of the skin is extremely rare, and in general the frequency of carcinoma in all countries, however caused, is in inverse proportion to the intensity of light."

The secretions of the genito-urinary glands are stimulated by light and cases of incontinence of urine improve on light treatment. The influence of light on the nervous system is marked and causes mental stimulation. Light creates a feeling of vigour and exhilaration and cheerfulness and a sense of well-being. Nervousness, insomnia and fatigue decrease. According to Dr. Wilcken, the people living in Disco island, Greenland, quarrel in the winter because the long spell of darkness 'gets on their nerves.' Moreover the staff of the meteorological Institutes in Buenos Aires and Lauri island, South Orkneys (61° 5′ latitude) report that they suffer frcm the depressing effects of long winters.

That there is an increased mental alertness of children on light treatment has been demonstrated by intelligence tests. The children at the Treloar Cripples Hospital at Alton appear to be mentally a year in advance of Crippled London Children of the same age. The following observations of Finsen are of interest

here :—'When the sun suddenly comes out, it is as if nature had been brought to life. The insects fly and hum gaily, the reptiles bask in the bright sunshine, the birds chirp and we ourselves get a feeling of well being and fullness of life.'

Dhar has emphasised that rickets is associated with the defective metabolism of fatty food materials. When the foodstuff lacks in vitamins A and D, which occur in butter, milk, codliver oil, but not in vegetable oils, the fat is not completely oxidized to carbonic acid and water, which are formed when the foodmaterials undergo proper and complete oxidation; the products of incomplete oxidation of foodstuffs are organic acids. It is well known that in rickets, acidity, which is due to the incomplete oxidation of food materials, is always observed. In presence of acids, calcuim carbonate and phosphate, which are the main ingredients of bone, cannot be deposited satisfactorily due to the solvent action of acids on calcium carbonate and phosphate. The proper treatment of rickets is to remove the acidity by improving and making the oxidation of fats in the animal body complete. This can be accomplished by vitamins A and D, alkalies and light, and all these agents accelerate the oxidation of fats.

From the researches of Palit and Dhar, it will be evident that fats are more readily oxidized by passing air in presence of light than the sugars and nitrogenous compounds. It appears, therefore, that in the animal body the light absorbed will also accelerate oxidation of fatty food materials to a greater extent than the proteins and carbohydrates and consequently light is more effective in the prevention and cure of rickets than that of gout and diabetes. As a matter of fact, light acts as a specific in the treatment of rickets, and this is explained from the researches of Palit and Dhar on photo-oxidation of food materials.

Pincussen [Biochem. Z. **150**, 36 (1924)] in his investigations on the effect of solar radiations on rabbits noticed a stimulation of the protein metabolism as shown by an increase in nitrogenous excretion. Sensitisers like the various dyestuffs and potassium iodide still further increase the nitrogen excretion.

Moreover, Rollier as well as Dhar have obtained marked

beneficial effect of sunlight in the treatment of diabetes, which is caused by the defective metabolism of glucose, although Sampson (Physio-therapy technique, St. Louis 1923) considers that diabetes is not amenable to ultraviolet light therapy, but he admits that this has not been the experience of others. Bach (Ultraviolet light, New York 1926) has successfully used ultraviolet light in the treatment of diabetic gangrene. Rothman observed that actinic erythema reduces pathological bloodsugar and glucose disappears from the urine but normal bloodsugar remains unaffected. Light treatment should not be combined with the administration of insulin, because in this case, bloodsugar appears to increase.

Chillblains and Raynand's disease have been successfully treated by light. Cruickshank and Walt (loc. cit.) report that visible light leads to a dilation of cutaneous vessels, stimulating the sweat glands and aiding the relief of deepseated congestion. Normal blood absorbs all radiations of wavelengths shorter than 4,500 A and has two other absorption bands at 5,400 A and 5,750 A

Finsen observed that there was a definite seasonal variation in the number of red blood corpuscles, the maximum occurring at the end of summer and the minimum at the end of winter. It is generally agreed that exposure to ultraviolet radiations increases the number of red blood corpuscles. Rollier has observed that there is a constant increase in the amount of haemoglobin and the number of red corpuscles in patients under light treatment. Blood estimations carried on with a large number of soldiers first in a temperate climate and then after their transportation to the tropics showed that the red corpuscles, and lymphocytes, were greatly increased in number and the polymorphs and the blood pressure decreased in the tropics.

It seems certain that visible ultraviolet light stimulates the haemopoietic system. Sunlight, ultraviolet light and heat increase the lymphocyte count. The number of blood platelets in the blood also rises on illumination. If an animal is kept in darkness and fed on a diet deficient in vitamin A, the number of blood

platelets decreases but they increase again on exposure to light. Blood platelets are believed to be part of the defensive mechanism of the body against bacterial infection.

The effect of ultraviolet light on human blood is to increase the red and white corpuscles and haemoglobin and lymphocytes and markedly the eosinophilic cells. The bactericidal and immunising power is also increased but the polymorphonuclear leucocytes decrease.

Light increases the amount of calcium, phosphorus, and iron in the blood, and tyrosin reaches its maximum during erythema production. It is perhaps because of these changes that light treatment is so valuable in rickets. Daily exposure for two minutes with a mercury vapour lamp at a distance of 3 ft., prevents rats from rickets, although kept in darkness and fed on a diet causing rickets, a similar dose given to a baby doubles the amount of phosphates in the blood in 15 days. The quality of milk of cows improves on exposing the cows to light.

Calcium salts are very important in many body reactions and have been assumed to be important agents in counteracting infection and repairing the damage caused by disease. Fatigue occurs when there is lack of calcium salts. During growth, pregnancy and lactation, large amounts of calcium salts are necessary. Calcium and phosphorus metabolism are influenced by relatively longer ultraviolet and visible rays; best results seem to arise from radiations 3,022 to 2,600 A, shorter wavelengths appear to be harmful.

On illumination, hyperglycaemia decreases but the iodine in the thyroid gland and the temperature increase, and the blood becomes more basic and hence in diabetes, acidosis and rickets, beneficial results arise from light treatment. On irradiation, the respiration becomes slower and deeper. The loss of appetite and congestion in the cirrhosis of the liver are remedied by light treatment. Bacterial infection of the bowel and diarrhoea are hindered.

In actual practice ultraviolet radiation is used either as the principal remedial agent or as an adjuvant to other therapeutic measures.

Orr, Henderson and Crichton (Trans. Highland and Agric. Soc. Scotland 1926) observed that when pigs 9 weeks old were subjected to light treatment from a carbon arc at a distance of 3 ft. for 1 hour daily, the amount of calcium and phosphorus, which the pigs were able to retain in their body was markedly increased, and the amounts excreted in the faeces were correspondingly diminished. Irradiation improves the leg-strength of young chickens. Orr, Henderson and Crichton state :—'It is suggested that there should be a fuller utilisation of sunshine for farm animals and the employment of artificial means of irradiation in winter is put forward as worthy of trial. The agriculturist should realise that the beneficial influence of sunshine falls not alone upon his crop but on all farm animals.'

What an important place light therapy occupies in modern medicine can be seen from the following lines from an 'Interim Report on artificial light and X-ray Therapy' by Cruickshank and Watt (published by the Scottish Board of Health 1925):

'Hitherto where growth has been deficient or function defective, we have had recourse to material remedies. In ultraviolet radiation a few form of treatment is at command. The extent of its therapeutic uses is as yet unknown but experimental investigation has shown that its therapeutic properties are in the main limited to conditions of growth or of function below normal. For example, it has been found to increase body weight, to increase the rate of growth, to improve the mineral content of the blood, to increase the functional activity of the endocrine glands, to increase the bactericidal power of the blood, etc., where they are below normal but to have no corresponding effect on normal individuals. We found in the course of our enquiry that without exception every patient undergoing light treatment experienced an improvement in his or her general feeling of well being, apart altogether from improvement or otherwise in the disease for which the treatment was being given.'

Ellis and Wells [Chemical action of ultraviolet Rays, page 270 (1925)] have made the following interesting statement regarding the comparative position of light therapy in medical science :—

'So far from serious burns being caused by ultraviolet rays, exposure to these very rays is becoming a favourable measure to relieve pain and to promote healing in ordinary burns, in X-ray dermatitis and in sunburn.

'Much of the practice in ultraviolet radiation is empirical. This is, however, true of most important advances in therapeutics. Quinine in malaria, mercury in syphilis, iron in chlorosis, ipicac in dysentery and the majority of our most valuable remedies entered in the pharmacopia, not through the portals of the pharmacologist's laboratory but in consequence of accidental discoveries, of lucky guesses and not infrequently with credentials endorsed by alchemists, astrologers, magicians and the medicne men of savage races.'

Finally I shall conclude this article with the opinions of several medical men and others regarding the efficiency of light treatment :

Dr. J. E. Lynham (Presidential Address—Royal Society of Medicine, 1929)—

'The case for the use of ultraviolet light, in skilled hands, is proved. The technique has been mastered, the effects are sure, and the results are so satisfactory that the treatment is now thoroughly established and recognised.'

Mr. Howard Stratford (Metropolitan Counties Branch, British Medical Association, Presidential Address, 1930)—

'Actinotherapy is most certainly a general practitioner's work.'

Dr. F. Hernaman-Johnson :—'If we can discover an agent which is effective in activating, at least in some degree, all these natural defensive organisms, then the diseases in which it is of value will obviously be numerous. An approach to such an agent we possess in ultra-violet rays.'

Dr. Justina Wilson (British Journal of Actinotherapy, Vol. 4, No. 1)—'In all conditions of marked debility, in convalescence from fever and other infections, in post operative conditions associated with loss of blood and anaemia, light is a great ally to physician and surgeon.'

Dr. Donovan, O.B.E. (Sunlight 1930)—'Light stimulates the patient's whole power over minor foci of disease. The patient feels well because these sources of infection have been destroyed by his own enhanced fighting power.'

Dr. S. Banks (British Journal of Actinotherapy, Vol. 3, No. 1) —'For over two years I have used the mercury vapour lamp in the wards of Isolation Hospital. As a general tonic in convalescence from all acute fevers, in poliomyelitis, in post-diphtheria paralysis, and as a tonic for the night staff, it should be in constant use.'

Report of the M. O. H. (Medical Officer of Health) Bristol 1927—'In the first six months a total of 114 children were treated. There is no question about the results in cases of rickets, after six or seven exposures, the legs are stronger and firmer and the child begins to walk better. Children suffering from general debility following an illness such as measles or influenza usually react well. We get reports of increased vitality, improvements in appetite and sleep and in most cases, there is a steady increase in weight. When a second course is suggested, there is never any need for persuasion.'

Report of the M.O.H. Bermondsey 1927—'Ante-natal cases have done remarkably well. Their general health is improved, they are generally more fit and do not suffer from depression and they have all had good confinements.'

Report of the M. O. H. Bethnal Green 1928—'Mothers, too, say that ultraviolet light has helped to cure their depression, and has made them feel stronger and healthier. Cases of failing breast milk through general ill health have so improved that they have maintained breast feeding throughout the whole nine months without recourse to any artificial substitute.'

Report of the M. O. H. Aberdeen 1927—'In cervieal adenitis, the results are uniformly good. Patients with tracheo-bronchial adenitis vary in their response; some recover rapidly, while others are very resistant to treatment. ....Pulmonary tuberculosis of the non-toxic type almost responds well to graduated irradition. The mercury vapour lamp is the source of choice, for its radiation

has few of the deep heating properties, which may cause pulmonary congestion.'

Major-General Seely speaking at a hospital meeting in London, said: "Nearly every disease can be cured by fresh air and sunshine. A distinguished scientific friend of mine said to me recently: 'In 20 years' time there will be only three means of treating the human body—surgery, bacteriology and heliotherapy. The third of these three will be the most important and all kinds of treatment now regarded as essential will disappear."

The following interesting observations appeared in a leading article on light therapy in the *Times* of 15th October 1927, 'There are few more remarkable movements in the history of medicine than the development, which has been witnessed recently in the use, for therapeutic purposes, of rays of various kinds. So great, indeed, and so rapid has this development been, and so wide are the horizons which extend before the science of actino-therapy, that already a kind of bewilderment exists about it in the professional mind. What is the truth about sunlight and artificial light? How far are these natural agencies of healing likely to take the place of existing methods? There can no longer be any dispute about the importance of radiological methods in the treatment of disease. Those who are aware of the revolution, which is now being accomplished in the healing of cases of so-called surgical tuberculosis realise that the methods, which twenty years ago were universally employed in the treatment of these severe ailments are applicable no longer. The work of the London Hospital in curing lupus is a triumph of the use of light as a therapeutic agent, and not less triumphant in its results is the work now being carried on in the treatment of surgical tuberculosis at the Lord Mayor Treloar Hospital at Alton and at other places. Light in all these has taken the place, to a great extent, of the surgeon's knife. It has achieved benefits for the patient, which no other agency has ever provided.'

Tansen as a Poet

By Suniti Kumar Chatterji (Calcutta).

Tānsen, or Tāna-sena, whose name is a household world all over India as one of the greatest exponents of the *Dhrūpad* (*Dhruva-pada*) or classical Hindu style of singing, was also a poet of rare power and felicity, judging from the songs he himself composed and set to the classical *Rāgas*, and in this way left them for posterity. Classical Indian music, i.e. Indian music going back to pre-Muhammadan times, as is well-known, has been continued in two traditional schools—that of the North (which is known as the Hindustānī or Hindusthānī school), and that of the South (known as the Karṇāṭak or Carnatic school). Tānsen for North India and Tyāga-rāya, the Telugu singer, devotee of Rāma (died 1850), for South India, are the two greatest names in the history of classical Indian music during the last few centuries. The Southern school is believed to be more faithful to the old Hindu tradition, to be purer and less influenced by extraneous systems, while the Northern one is regarded as being less pure, having imbibed extra-Indian influences and developed in a different way from the other school. The Hindusthānī school has adopted a great many things from Muhammadan, i.e. Persian, Arab and Turkī (Central Asian) music, no doubt; in this way it is richer if less pure than the Karṇāṭak school. But it has preserved a great many things intact, too—has undoubtedly preserved a considerable portion of the old pre-Muhammadan music, at least as well as the Southern school; and it is in the *Dhrūpad* style of singing, with the special accompaniment of the *pakhāwaj* drum, the three-stringed *tambūrā* (or *tānapūra*), and the North Indian *vīṇā* or lute, that we see the finished Hindu music of a thousand years ago or more. The *Dhrūpad* tradition with its *Rāgas* and *Rāgiṇīs* and

its *Tālas* certainly harks back to indegenous Hindu music of pre-Muhammadan times. Later developments, with a judicious commingling of elements from the music (chiefly of Persia and Central Asia) brought in by the Turkī conquerors of India, are believed to have given rise to the *Khyāl* style in the 13th century, then to the *Ṭappā* style, and finally the *Ṭhumrī* style in the 19th century. The process has been one of elaboration. Nothing in Indian music approaches the stately simplicity, the nobility, the majesty and grandeur of the *Dhrūpad*. The succession of notes in a *Dhrūpad* song resembles the simple, severe and noble lines of a Dorian temple. Music naturally calls for comparison with architecture among the plastic arts, and the effect produced by *Dhrūpad* singing, with its proper accompaniment, irresistibly evokes this comparison. *Khyāl* would then be like a rather ornate temple in the Ionic order, *Ṭappā* would suggest the Corinthian or Roman order, and *Ṭhumrī* the Rococo. *Dhrūpad* is music in the grand style—the veritable epic of music. *Dhrūpad* suggests great sculpture, simple and powerful, like those at Mahābalipuram or Elephanta, and *Ṭappā* and *Ṭhumrī* the infinitely complicated lines and arabesques and highly bejewelled figures of later Hindu sculpture. Great as the *Dhrūpad* of the present day is, basing itself on the tradition as finally closed by Tānsen and his peers in the 16th and 17th centuries, we can imagine that it was greater and statelier still in the 5th-6th centuries A.D. In the other departments of Indian Hindu culture, we have an age of preparation in the centuries preceding Christ; the formation and flourishing of the classical culture, during the greater part of the first thousand years after Christ; and finally, the decay, with the impact of the fury of the Turkish invasion; and then a fresh rejuvenation under the Indianised and Indian Muhammadan dynasties. In music also probably a parallel line of development took place. Sanskrit, Prakrit, Apabhraṃśa, and Bhāṣā or Modern Vernacular: these are the stages, roughly, in the development of the Aryan speech in India. In the *Dhrūpad*, we have the Bhāṣā, and probably also the Apabhraṃśa stages: its earlier, Prakrit phases, and its oldest

phase, comparable to Sanskrit, have perhaps been lost for ever. But *Dhrūpad* can give us some idea of what it was like. Our present day 'classical' tradition is thus, at the best, but medieval in point of time.

Be it as it may, we have to be grateful to masters like Gopāl Nāyak, Amīr Khusrau, Haridās Swāmī, Baijū Bāware, Tānsen, Sadāraṅg, Shorī Miyān and others for what they did for Indian music. They were innovators, some of them, and bold innovators, too: for example Amīr Khusrau, the reputed initiator of the *Khyāl* style; and Tānsen himself is said to have modified some old *Rāgas*, e.g. the *Rāga Malhār*, which as modified by him came to be known as the *Miyān-kī Malhār*, and the noble *Rāga* known as *Darbārī Kānaṛā* was his creation. But mainly they were conservators. Their anxiety to preserve the 'classic' modes and melodies and styles has been the instrument for the preservation, even in a fragmentary form, of our medieval and probably also of our ancient music.*

Tānsen's association with Akbar has been a fortunate circumstance to which we are thankful for some details about his life and for some stories regarding his genius and achievement. Contemporary art, too, has given us his portrait: we have a few Mogul miniatures representing Tānsen, which presumbly were executed in the days of Jahāngīr. In one of these his name is actually written beside his portrait: he is seen here, a slight figure of a man,

* It has been suggested by some that the *Dhrūpad* tradition and the *Dhrūpad* style are now dead—their cultivation may be compared to that of a classical language like Sanskrit or Greek. This is not really the case. It is a style of music which may not be the fashion now, but it is a living style and a living tradition none the less. New melodies are composed in the *Dhrūpad* style in the same way they used to be in the days of Tānsen. As an instance of how a new *Dhrūpad* melody may be inspired in these later days, we may mention that a short while ago Saṅgīta-ratnākara Surendranāth Banerji (of the famous Viṣṇupur family of singers and musicians) composed a fine new melody which he called *Rāga Gāndhī*, celebrating Mahātmā Gāndhī's fast as a protest against social injustices among Hindus. In fact the *Dhrūpad* could never have persisted to our day if it were merly repeating fixed and stereotyped *Rāgas* only, if new creation had not been taking place. This is certainly a sign of life and growth, and not of death or stagnation.

very dark, with a thin wisp of a moustache, in company with Jahāngīr, the son and successor of his illustrious patron. This picture may represent a meeting when Jahāngīr was a prince, and Jahāngīr himself in his autobiography has declared his admiration for Tānsen. In the second, he is playing on a lute in a company of court musicians in the courtyard of the imperial palace, while arrangements are being made for a state procession: this picture also refers to the times of Jahāngīr. These two pictures may be said to give the portrait of the man Tānsen as he really was. In the third one, which is more a subject composition than a strictly historical picture, he appears as a much younger man, but with the same slight dark figure, devoutly squatting on the ground and listening with deep respect, with the emperor Akbar standing beside him, to his master Haridās Swāmī playing on the *tambūrā* and singing in his hermitage. The emperor in his jewels and with his halo has come to the saintly musician's hermitage on foot, leaving his pomp and power afar, with figures of squatting camels and tents seen from a distance. This picture illustrates the beautiful story of Akbar going all the way to the hermitage of the saint at Brindāban to listen to his singing, as the latter would not come to the Court; Akbar was led there by Tānsen, and the latter by a ruse made the saint sing, and his singing affected Akbar so much that he fell into an ecstatic trance, and when he recovered he asked Tānsen why he (Tānsen) could not sing like Haridās Swāmī; and Tānsen made the reply, that he sang for the pleasure of an earthly ruler, whereas his master Haridās Swāmī did it for that of the Ruler of the Universe.

And yet, Tānsen's life and career remains a mystery. He is mentioned by Abū-l-Fazl, one of his fellow-courtiers, in his *Āyīn-i-Akbarī*, in which his name is given first in a list of the most skillful musicians of Akbar's court—36 in number: and Abū-l-Fazl expresses the current enthusiasm for him in this line: 'a singer like him has not been in India for the last thousand years'. We have a short biographical note on Tānsen by Śiv Siṃh Seṅgar in his *Śiv-siṃh-Saroj*, an anthology of Hindī poets, with brief

biographical notes, which was first published *Saṃvat* 1934 (= 1877-1878); and this has been reproduced by Grierson in his *Modern Vernacular Literature of Hindustan* (1889). Śiv Siṃh gives 1588 *Saṃvat* (= 1531-1532) as the year of Tānsen's birth, but he does not quote any authority. Tānsen must have been born at least a decade earlier, as this date does not accord at all with the other events in his life. Tānsen died in April 1589 (A. H. 997), as we learn from contemporary court histories in Persian. Tānsen was the son of a Gauḍ Brāhmaṇ named Makarand Pāṇḍe. He first learned the art of versification and singing from the Vaiṣṇava saint Haridās Swāmī of Brindāban. Later he learned the art from the Sūfī saint Shaikh Muhammad Ghaus of Gwalior. Muhammad Ghaus is said to have been a great musician, the greatest among Muhammadans, and he lived in the days of Bābar, Humāyūn and Akbar, and was much venerated by the people. It was through a stratagem suggested by this holy Muslim saint that Bābar's general Rahīmdād could capture the fort of Gwalior from the Hindus. It is said that he touched Tānsen's tongue with his own, and in this way transmitted to Tānsen his own great skill in singing. Tānsen became a Muhammadan subsequent to his coming to the court of Akbar in 1562. We do not know what prompted him to declare this open allegiance to the faith of Islām. It was certainly not through hope of preferment at court, as his master Akbar was not a bigoted Muslim. At heart Tānsen remained always a Hindu, and a devout Hindu, judging from his songs. The few songs which he composed praising Muhammadan saints and the prophet lack the depth and sincerity of his songs of Hindu inspiration. Was it the personal influence of Muhammad Ghaus which made him accept the Muhammadan name formally, without perhaps abjuring anything of his Hindu mentality? Muhammad Ghaus became quite respected as a saint in his old age, and he was polite equally to Hindus and Muhammadans, which made him not a little unpopular with the ultra-orthodox Musalmāns. This might have made him popular with the Hindus: and the popularity of a Muhammadan saint—a *Pīr* or *Faqīr*—has frequently won converts to Islām. Or was it because Tānsen was outcasted, as

he was hobnobbing too much with Muhammadans? Śiv Siṃh notes that Tānsen became enamoured of Daulat Khān, a son of Sher Shāh, the Paṭhān emperor who ousted Humāyūn (he became a lover, *'āshiq*, of Daulat Khān, in the language of Śiv Siṃh). Daulat Khān was evidently a young patron, and Tānsen is said to have composed many poems in his honour. This little story gives an interesting side-light into Muhammadan ideas and manners of those days. Another reason why Tānsen became a Muhammadan may be sought in the possibility of an *en masse* conversion, perhaps forcible, of a large section of the group or clan to which Tānsen himself belonged. Gwalior had become an important centre of Hindu art—architecture and music specially—during the rule of Rājā Mān Siṃh Tomar (1486-1518), and Gwalior musicians had become famous as exponents of classical Hindu music. Abū-l-Fazl's list of the most famous singers and musicians of the court of Akbar gives us 36 names, Indian and foreign (Persian and Central Asian); and of these 36, no less than 15 are artists from Gwalior. And it is curious to note that most of these 15 Gwalior men are Muhammadans with Hindu names—same as in the case of Miyān (Mīrzā) Tānsen. We have Tāntaraṅg Khān, a son of Tānsen; and others have names like Śrīgyān Khān, Miyān Chand, Bichitr Khān (his brother Subhān Khān has a Muhammadan name), Bīr Maṇḍal Khān, Parbīn Khān, Chand Khān. The conversion of these exponents of ancient Hindu music would appear to be inexplicable, but cases of forcible group-conversion are not unknown in the history of Indian Islām. We can mention the case of the Malkhānā Rājpūts of the U. P. and Rajputana, and the Chitrakars of Bengal, two Hindu castes which have been unwilling subjects of Islām and are now coming back to the Hindu fold once again. A forcible conversion of the Brāhmaṇ singers who in and about Gwalior carried on the ancient art, some time during the 15th or early 16th century, when Gwalior was a bone of contention among the Rājpūts and the Paṭhān and Mogul and other Muhammadan powers, might have been responsible for what would appear to be the nominal affiliation of Tānsen and his *birādarī* of Gauḍ Brāhmaṇ musicians to Islām. Social sym

pathy is often responsible for smaller groups to accept the fate of a larger one. Yet another reason for Tānsen's conversion may be love, and this is hinted at by an apocryphal story, impossible in its absurdity, that Akbar married one of his daughters to Tānsen before the latter could be persuaded to sing before him; 'cherchez la femme' : the charms of a lady of some Muhammadan family may have drawn Tānsen away. So that one or more of these four factors must have operated—personal influence of Muhammad Ghaus, his *ustād* or master in singing; close contact with the Muhammadan bloods of the time, which might have brought about social obloquy and perhaps ostracism from his more strict Brāhmaṇ caste-fellows; forcible *en masse* conversion of his clan; and finally, his love for some Musalmānī girl. Be it as it may, the influence of Muhammad Ghaus appears to have been one of the factors in his career. After his death he was interred, it may be by his own express desire, beside the fine mausoleum over the grave of Muhammad Ghaus, at the foot of the rock *massif* of the fort of Gwalior. This tomb of Tānsen is quite a place of pilgrimage for the singers of Hindustān, who fondly chew the acid leaves of the tamarind tree close to his tomb, with the idea that owing to the proximity of the tree to the grave of the master-singer its leaves will impart a sweetness to the voice.

After the death of his master Daulat Khān, Tānsen found a Fresh patron in Rājā Rām Chand Siṃh Baghelā of Bāndhaw in Rīwān (Rewa) state in Central India, and his largesses to the singer were extravagantly generous. Meanwhile Tānsen's fame had spread on all sides; and Ibrāhīm Khān Sūr, a successor of Sher Shāh, is said to have tried to induce Tānsen to come to the Agra court, but in vain. Akbar, well-established as a strong ruler, had heard about him and wanted to have him in his court. In 1562 Akbar sent one of his noblemen Jalāl-uddīn Qurchī to Rīwān to bring Tānsen to Agra. The rest of Tānsen's career would appear to have been uneventful, excepting his conversion to Islām, which however could not have exerted any great influence on his artistic or spiritual life. It would seem he lived a life of quiet dedication to his art—composing his songs

and singing before his master in private audience or in court functions, and obtaining the universal homage that is the true artist's due. Probably he trained his relations and pupils: his sons followed in his footsteps, and his descendants still live, in the state of Rāmpur and elsewhere, carrying on the musical tradition associated with the name of their great ancestor. We hear about his disciples also, as having been eminent musicians and singers.

Great as Tānsen was in singing, he was a great poet as well. He lived in what may be called the golden age of Hindī poetry; and among his contemporaries were some of the greatest poets of Hindī, two of whom, Tulasīdās and Sūrdās (an elder contemporary) are in the forefront of Indian literature. Akbar's court was a centre of Hindī poetry, as it was of Persian and other learning; and the great emperor himself is credited with having composed verses in Hindī (Braj-bhākhā) in which he signs his names as *Akabbara* or *Akabbara Sāhī*. Among his courtiers persons were not lacking who were distinguished names in Hindī poetry, like Mīrzā 'Abdu-r-Rahīm Khān-Khānān, Bīrbal, and Prithwīrāj Rāṭhoṛ of Bīkāner (the Rājpūt prince who composed, not in Hindī or *Braj* but in this own Rājasthānī dialect of *Ḍiṅgal*). It seems Tānsen's fame as a singer has cast into shade his greatness as a poet. One reason for this was that Tānsen was not a professed poet,—he did not compose any long narrative poem, nor stanzas and distichs meant to be chanted as poetry. But he was a lyrist in the true sense of the term, as his poems were songs which he sang himself; and it was their music which had the first appeal rather than their poetry which had only a secondary importance. Tānsen had as his peers similar poet-musicians in the court of Akbar—notably Bābā Rāmdās and his son Sūrdās (who has been confused with the great Hindī poet of that name, the other Sūrdās, the blind poet of Brindāban, who sang of Rādhā and Kṛṣṇa, and flourished considerably earlier).

Not being in the first instance considered as a poet, Tānsen's compositions did not attract the attention they deserved from the North Indian public. The critics and copyists were occupied with

Sūrdās and Bihārīlāl, Tulasīdās and Bhūṣaṇ, and the rest. Outside of the select circle of the singers practising classical music, which was quite a jealous caste, and which preserved what it could of the master's composition, ordinary people honoured his name as a great singer but otherwise cared little for him. To my knowledge, no special anthology of Tānsen's songs has been made, although all books on North Indian music will be sure to include some of them. Fortunately, Tānsen followed the practise of the Hindī (and other North Indian, and Persian) poets of the age in signing his songs. This would give us the cue in identifying his compositions. It is likely that a good many poems that were really not his have come to be associated with his name: and some of his own compositions similarly came to be associated with other poet-singers. A critical edition of Tānsen's songs is a *desideratum* in Hindī literature: the songs considered as literature, and not as vehicles of classical music. There is quite a goodly mass of material to work upon. The *Saṅgīta-Rāga-ḳalpa-druma* of Kṛṣṇānanda Vyāsa-deva (first published, Calcutta 1843: second edition, Vaṅgīya Sāhitya Pariṣad, Calcutta, three vols., 1914-1916) gives a goodly number with the signature of Tānsen. This can be supplemented by what is available from other music anthologies, in Hindī and in the other North Indian languages. A good few can be had from treatises in the Bengali language on Indian music. One may mention for instance, the works of Saṅgīta-nāyaka Gopeśwar Banerji, perhaps the ablest exponent of the *Dhrūpad* tradition as preserved in Bengal. Another such collection is a little work (quite useful inspite of the mutilation of the Hindī words in every line) named *Dhrupad Bhajanāvalī*, an anthology in Bengali characters compiled by Babu Ramlal Maitra of Rangpur in Northern Bengal giving some 371 *Dhrūpad* songs, of which over 180 have the signature of Tānsen.

Tānsen, like most poets of the Western Hindī area, composed in the *Braj-bhāḳhā* dialect, which, spoken in and about Mathurā and Brindāban in its purest form, is one of the most highly cultivated Aryan speeches of India, and a perfect vehicle for lyric poetry. Standard Literary Hindī of the present day, and Urdū which has

been aptly described as 'Musalmānī Hindī', had not as yet evolved out of the conflict of dialects that was going on then. As a medieval Indian language, it is rich in vowels, and words in it always end in vowels. This fits it with a special suitability for songs, especially of a elevated tone. One tradition in pronunciation which characterises this dialect when used in lyrics or songs—current at the present day at least among certain schools—is to turn a short *a* before a group of a nasal plus stop (simple or aspirated) into the diphthong *au* (nowadays pronounced something like the *aw* or *au* in English *law* or *Paul*), in which the following nasal element is long drawn out, which gives an added sonority and dignity to a verse when drawn out in the tune: e.g. *paṅkaja, saṅkha, gaṅga, pañca, añjana, maṇḍala, anta, canda, sugandha, ambha,* are pronounced as *pauṅkaja, sauṅkha, gauṅga, pauñca, auñjana, mauṇḍala, aunta, caunda, sugaundha, aumbha.*

One great point with his poems (as with similar lyrics by other Hindī poets of his time) is the terseness of language. Grammar is reduced to a minimum, post-positions and other help-words are admitted only when absolutely necessary: even inflexions are clipped,—the mere base of the noun or the verb doing duty for the inflected form. The sentence resolves itself into a succession of whole words, solid words and compounds, which in their isolated position become imbued with a sort of grandeur and intensity otherwise unattainable. We have frequently in the lines of Tānsen a succession of pictures evoked by the mere word—the topic being familiar to his audience.

The poems fit in which the exigencies of *Dhrūpad* singing, and consequently corresponding to the four parts of the *Dhrūpad*—*Asthāyī, Antarā, Sañcārī* and *Ābhog,* there are four parts. The metres are usually those of four long lines, like *Caupaiyā, Sawāyā, Tribhaṅgī, Padmāwatī, Līlāwatī, Hiṇḍola, Duramilā, Madanaharā;* and frequently we have prose.

This is the formal range of Tānsen's poetry—his muse must be confined within the limited extent of a four-lined stanza. This was a self-imposed handicap. In the range of his subjects, he allowed himself but slightly greater variety. Herein the conven-

tion that allowed only particular subjects as suitable for the *Dhrūpad* jealously prevented him from essaying many other sentiments. *Dhrūpad* music as being of an exalted kind could only have exalted subjects: praise of the Supreme Being, or of the various aspects of the Deity—the various Gods and Goddesses of the Hindu pantheon; descriptions of the Gods, their greatness and their sports (*līlā*); descriptions of Nature, specially of the Seasons; celebration of music; love, specially that of Rādhā and Kṛṣṇa; praise of kings and rulers; and under Muhammadan inspiration, praise of Allāh, of the prophet Muhammad, and of Muhammadan saints, living and dead, Indian and foreign. The vocabulary of *Dhrūpad* songs was that of Old Braj-bhākhā poetry; that is, Old Hindī and Sanskrit words by preterence, as Persian and Arab vocables had not yet made much impression on the Indian languages: but in the songs of Muhammadan inspiration, Persian and Arabic words and phrases occasionally have full play.

This was the limited range of subjects for *Dhrūpad* lyrics. The form was even more limited. The poet's choice of words also had to take cognisance of the melody: but this was an advantage as much as a disadvantage, for it ensured an indissoluble welding together of his sentiments and his music. On the whole, there were thus some serious handicaps. Yet within this narrow scope, Tānsen shows his genius remarkably well. The stateliness of the form and its balanced architectural quality, to start with, elevates his compositions; and this elevation is further sustained by the nobilty of his diction and the aptness of the words he selects. The very terms and epithets with which, for instance, the Gods in their majesty are described, evoke pictures which have a stamp of primeval grandeur about them. Thus, for instance, in some of the hymns to the Supreme (Para-brahma), and to Śiva and Viṣṇu. The brightness of the spring, with the birds singing and the south breeze blowing; the rainy season, with its gusts of the easterly wind, its dark tropical clouds, the clouds' rumble and the lightning's flash, and the incessant patter of rain heard on the terrace, on leaves of trees and on sheets of water; the tenderness and the idyllic

love of the divine lovers Rādhā and Kṛṣṇa, typifying the quest of the soul for God, and its final union with the Godhead: all these, and a score of other things—the sublimest and the sweetest in Indian poetry—find a jewelled setting as it were in these *Dhrūpad* poems. We have in them the concentration of classical and medieval Hindu poetry and devotion. These *Dhrūpad* poems, with the analogous *Rāga-mālā* poems (explaining the Rājpūt and Mogul miniatures on the subject), are among the choicest flowers in the garden of Indian poetry. Tānsen is in the direct line of the ancient and medieval poets of India, from the Rigvedic period downwards.

He is a court singer and a court poet, being in attendance on one of the greatest rulers of men that history knows. Yet his themes are the property of the common people of India,—they relate to things which the humble tiller of the soil understands and loves, as much as the scholar and the aristocrat, the soldier and the tradesman: *āvir akṛta priyāṇi*: he has revealed the things we love. His poetry is a product of the race-mind—it is national, and popular, in the truest sense of the terms.

In the mass of the poems, it is not possible to trace any chronological arrangement or development. It has been suggested (in the introduction to Mr. Ramlal Maitra's anthology of *Dhrūpad* songs mentioned above) that Tānsen's life as a poet falls in three periods—that of his young age, his manhood, and his old age. In the songs of the first period he celebrated his princely patrons, and treated of Nature and the Seasons: these are gay and light in temperament. In his second period, he treated of the Gods and their glory: but in these one does not get any depth of feeling; and in the third period, Tānsen composed poems on the love of Kṛṣṇa and Rādhā, and these poems showing his *bhakti* are the most profound in spirit, and these carry away the listener in a stream of passionate faith in God. In their poetry, too, these last are said to be supreme. Now, from a study of the songs themselves, it would appear that this classification into periods is arbitrary, and the grouping of the songs with reference to the profundity of sentiment is largely subjective.

But there is no denying the fact that some of Tānsen's poems of praise and prayer are as sincere and as profound as those of the greatest saints of India. Tānsen's lyrics, the purely religious ones as well as those which may be described as 'secular' (e.g. descriptions of Nature), in their very simple manner certainly do reveal a mystic and a man of deep piety. He is a true Brāhmaṇ in his poems, and one of the best cultured, too, in the lore and the thought of India. He is keenly alive to the grandeur and the profundity underlying the conception of Śiva and Viṣṇu, of Sūrya and Gaṇeśa, of Devī and Sarasvatī. He also reveals himself as a pantheist of the noblest type in some of his poems. He is a true inheritor of all the wisdom and the beauty which Hindu culture produced, from the Vedas to the Upaniṣads, and the Mahābhārata and the Rāmāyaṇa and the Purāṇas, down to the Tantras and the *Bhakti-mārga* Saints of Medieval India. And his songs have been known to induce the ecstatic condition of prayer in the listener. Some of his prayers ring quite sincere in their note of despair as a man and sinner—the *Eli Eli lama sabachthani* cry is here softened by an overpowering sense of God's mercy and his ever being with us.

The *Dhrūpad* poems are fittest to be sung before an image of the Deity in a temple, or in a select company in a drawing-room, or up on a terrace in the moon-lit night, or in some quiet hermitage or grove by a great water or river under the star-lit sky of a dark night. In the *Kādambarī* of Bāṇa-bhaṭṭa, the Sanskrit writer of the 7th century A.D., we have the exquisite picture of Mahāśvetā, the young princess, mourning for her absent lover, and singing to the accompaniment of a *vīṇā* in front of the image of Śiva in a temple by the Acchoda lake: and the song in praise of Śiva that she sang was certainly the classic Gupta counterpart of our familiar 16th century *Dhrūpad*. And the forlorn wife of the Yakṣa in the *Megha-dūta* of Kālidāsa, trying to while away the pangs of separation by playing on her *vīṇā* and singing: what else would she sing, except songs of separation —*viraha*—in some grand old *Rāga*, and in the *Dhrūpad* style? Certainly, the music that nature makes in praise of God—the music

of an elevated and ecstatic type in which Śiva is praised in the mountain glades of the Himālayas, when the wind pipes through the slender hollow bamboo, and the celestial nymphs—*Kinnarīs*—are singing in unison, and the thunder of the clouds echoing from the caves of the mountains form the deep drum-beat—that music finds its expression through the *Dhrūpad*. Similarly, the eternal quest of Rādhā and Kṛṣṇa for each other has its perfect musical expression in the words and the *Rāgas* and the *Tālas* of the songs of the *Gīta-govinda*. I have attended the most impressive religious services of the Roman Catholic Church, and those of Hinduism. Temple chanting of various sorts I recall,—e.g. in the great Viṣṇu and Śiva temples of the Tamil-land in South India, in the Puri temple, at Benares, and elsewhere: I have been impressed by the greatness of the religious chanting everywhere. But I recall with special pleasure the early morning service I witnessed in the Śiva shrine of *Ekliṅgjī* (*Ekaliṅga-nātha*) near Udaipur, where during the intervals that the shrine-door was closed, when the Sanskrit *mantras* would not be heard for a while, an old singer with a *sāraṅgī* lute and an attendant with a *pakhāwaj* drum struck up a *Dhrūpad* song of praise, the effect of which amid the impressive silence and in the carved porch-hall of the temple could be well imagined. We have a good many Rājpūt and Mogul miniatures from the 16th century onwards giving us the ideal setting for a discourse of music in the *Dhrūpad* style: a princess, alone or accompanied by a maid, singing and playing on the *vīṇā* before a Śiva image, in a forest glade in the depth of the night, or in the glory of an early autumn morning; musicians and *Yogīs* discoursing music in a river-side hermitage, the picture itself a nocturne of wonderful power; a maiden looking wistfully at a cloudy sky. The scenes in the *Rāga-mālā* pictures are 'visualised music', the music of the *Dhrūpad*. In fact, in the *Dhrūpad* songs and in the Rājpūt and Mogul *Rāga* pictures (in the Rājpūt miniatures especially), we have a remarkable co-operation or parallelism of music and art.

I shall close by giving a few poems of Tānsen (some ten), in Romanised original and in translation, the texts being slightly

emended and corrected from the very corrupt traditional or printed versions. These would give a fair idea of Tānsen's achievement as a poet. The songs to the Dawn are quite reminiscitory of Rig-veda poetry.

[1] Rāga Lalita-Bhairawa. Tāla Cautāla.

hema-kirīṭinī Ukhā dewī kanaka-baranī sawitā-gehinī udata madhura hāsa jaga hasāyau.

sindhu-bāri udata Bhānu, bimala soha jaise mānaun diśā-nāyarī kanaka gāgarī pānī bhari bhari maṅgala-asnāna karāyau.

bihaga madhura lalita tāna gāwai, bhuwana nawa jīwana, ānanda-magana saba jaga-jana maṅgala-gīta gāyau.

āyī Ukhā, kawanla-netrī, gāyatrī, jaga-dhātrī, leke aruṇa-kiraṇa-mañjana Tānasena mānasa-tāmasa dūra liyau.

(A Hymn to the Dawn Goddess)

Golden-crowned Ushas, Goddess of Dawn, Golden-hued, Spouse of the Sun, she is rising, and has made the world smile with her sweet smile.

The Sun is rising from the waters of the Sea: the pure beauty (of the scene)—as if the Nymphs of the quarters of the sky have bathed him in an auspicious bath, filling and refilling with water golden jars.

The birds are singing in sweet and soft notes: there is new life on earth, and all men on earth deep in bliss sing a song of joy.

Ushas has come, lotus-eyed Songstress (Gāyatrī), the Sustainer of the Universe: taking the rays of the Young Sun as a collyrium, she has removed afar the darkness that is in the mind of Tānasena.

[2] Rāga Bhairawa. Tāla Dhīmā Titālā.

Mahādewa Mahākala Dhurajaṭī Śūlī Pañca-badana Prasanna-netra.

Parameśwara Parātpara Mahā-jogī Maheśwara Parama-purukha Premamaya Para-śānti-dātā.

saritā-gaṇa bhinna bhinna pantha jaise āwata, sindhuwā pāi rahata magana,

Tānsena kahai taise bhagata bhinna mūrati upāsata eka hī Bramha āwata.

(A Hymn to Śiva)

Great God, Great Time, Bearer of matted locks on Thy head, Trident-holder, Five-faced, with eyes that are gracious:

Supreme Lord, Supreme of the Supreme, Great Yogī, Great Lord, Supreme Person, Soul of Love, Giver of Supreme Peace.

As streams come along different ways and become merged on reaching the Ocean—

Tānasena says: so devotees worshipping different images (manifestations) come to the one Brahma.

[3] Rāgiṇī Lalitā. Tāla Cautāla.

gagana-maṇḍala-madhya Udayācala-para aṣṭa-bājī kaṅakā-ratha-men Aruṇa-sārathi hota priyā Ukhā sawen aruṇa-barana raṅgī basana pahiri Bhānu udata.

gaganāṅgana andhāra-dhūriyā kiraṇa-mañjana dūra liyā, hullāsa Prakriti hasata amiyā, bicitra bhūkhaṇa mohana sājata.

kānana-kuntala nīhāra-būndana jaṛita mukutā-māla mānon, sindhu nicola, acala mekhalā, nitamba dharaṇī biśāla.

bālārka sindūra-būnda bhāla, graha-uṛa-sapta-rikhi-maṇḍala sohata: Prakriti-soha nihāri Tānasena prāṇa matāwata.

(Morning)

In the vault of the sky, upon the Mountain of Sunrise, the Sun rises in his eight-horsed chariot of gold, with Aruṇa as his charioteer, accompanied by his beloved Ushas, putting on a coloured garment of rosy hue.

Darkness has been removed like dust from the court-yard of the sky through sweeping with his rays: in joy Nature smiles ambrosia, and dresses herself charmingly with wonderful adornments.

The woods, like (Nature's) tresses, seem to be done up with the dew-drops as with strings of pearls: the sea is the (blue) breast cloth, the mountain chains the zone ornament, and the wide earth is the broad hip (of Nature).

She has the young sun as a red vermilion patch on her fore-

head: the planets and the stars, the group of the Seven Sages (the Seven Stars of the Great Bear), appear beautiful: seeing all this beauty of Nature, Tānasena's soul is intoxicated.

[4] Rāgiṇī Bhairawī. Tāla Cautāla.

anta-kāla kripā karo hiyā-para ṭhāṛau, Hari Kawanla-naina Kawanlā-pati muralī-adhara lalita-madhura baṅkima bha-i Baṅka-bihārī.

badana khīna, indriya hīna, pāpa suwanri asthira prāṇa, nirāśā prabara, biśwa andhāra, geha choṛi prāṇa jāta Hari.

bikhaya āpada sukha sampada dhana-jana-dārā-bāndhawa-suta saba-ko choṛi calihaun, eka karama aba saṅgi rahiyau.

Patita-pāwana Prabhu Janārdana, patita dīna Tānasena, Biśwa-mohana, pāra-gāmī prāṇa āśraya dīje, Goloka-bihārī.

(*A Prayer to Kṛṣṇa the Saviour*)

Give me Thy grace when my end comes, taking Thy stand in my heart, O Hari, Lotus-eyed, Lord of Kamalā (Śrī), with thy flute at Thy lips, and in Thy side-way pose so sweet and beautiful, O Lord of Sport that standest awrily.

My frame (face) is weak, miserable my senses: my soul is restless, remembering my sins: despair is strong, the Universe is dark for me; O Hari, my life is passing away, leaving its abode.

My estates, my pleasures and possessions are a tribulation to me: I shall depart alone, leaving behind all my riches and men and wife and relations and sons: my actions alone remain with me.

Saviour of the fallen, Master, Slayer of the demon Jana, Tānasena has sinned and is miserable: O Charmer of the Universe, my life is passing on to the other shore; vouchsafe it refuge, O Dweller in the Paradise of Goloka!

[5] Rāgiṇī Darbārī Toṛī. Tāla Cautāla.

prāṇa merau hī rota hai biraha Prāṇa-ballaha niśi-dina, he Hari śaraṇāgata dīna-ko darasana kāhe na mila.

ḍhūnṛi hirda na pāwe nidhi, yā bidhi terī bidhi, Hirda-nātha Dīna-nātha, kauna gati kīna mere aparādha-ke phala.

sūna prāṇa, sūna mana, sūna hirda-āsana; andhāra bhayau biśwa-saṃsāra, he Nātha.

Tānasena binati karata, āi hirda Jagannātha maru-bhūma prema-bāri barakhi prāṇa kīje śītala.

(*A Prayer to Viṣṇu*)

My soul weeps for separation day and night, O Lord of my Soul: O Hari, why is not a sight of Thee vouchsafed to this miserable one, seeking refuge in Thee?

The jewel is sought for, but not found in the heart: this ordination is Thy ordination. Lord of my Heart, Lord of the miserable, as the fruit of my sins what Fate hast Thou ordained for me?

Void is my soul, void my mind, and empty the seat of my heart: the entire Universe is dark for me, O Lord.

Tānasena makes prayer: O Lord of the World, do Thou make my restless soul cool, coming to my heart and raining upon the desert land the waters of love.

[6] Rāgiṇī Alaiyā. Tāla Cautāla.

jagata-jīwana hau Prabhu, bhagata-bacchala Tūn hī Bhagawāna.

Bhagata-hiya-paṅkaja-rāja Acala-rāja Rājarājeśwara Agaṇa-bhuwana-pālaka.

Tūn hī mātā, Tūn hī pātā, Tūn hī dhātā bāndhawa, Tūn hī priya prāṇārāma Tūn hī para śānti, sukha gati, moccha-bhakti-dātā Bramha Tāraka.

Nanda-nandana Hirda-rañjana Bhaya-bhañjana Ripu-gañjana, Nārāyaṇa, Purukha-ratana, Ananta, Anādi, Biśwa-nātha.

Prāṇa-ballaha, Bahu-ballaha, Tānasena-kau eka Ballaha: māyā-moha-mugadha cīta saṃsāra-tāpa tapata: Śānti-dātā, dīje śānti dīna-kau.

(*A Prayer to Kṛṣṇa*)

Lord, Thou art the Life of the World, Thou art full of grace to Thy servants, Thou art God: King of the lotus of the heart of

Thy devotees, King unmoved, Lord of kings, Protector of unnumbered Worlds.

Thou art the Mother, Thou art the Protector, Thou art the Creator, Friend and Beloved Thou, Thou art the Repose of the Soul, Supreme Peace, Blissful Existence, Giver of Salvation, of Faith supreme, O Brahma the Saviour.

Thou the Son of Nanda, the Charmer of Heart, the Destroyer of Fear, the Suppressor of the Enemy, Son of Man, Gem of Men, Unending, Beginningless, Lord of the World.

Thou art the Lord and Lover of my soul, Lord and Lover of Many, the one Lord and Lover of Tānasena; my mind is bewildered by Illusion and by Ignorance, and is suffering from the torments of life: Bestower of Peace, grant Thou peace to this wretch.

[7] Rāgiṇī Hiṇḍola. Tāla Cautāla.

sundara sarasa ritu-rāja Basanta āwata bhāwana, kuñja kuñja phūli phūli bhawanra guñja, koyila pañcama gāna matāwe nara-nārī.

kānana kānana phūṭata camelī bakula gandha-rāja belī, motiyā gulāba sugandha manohārī.

Pawana calata manda manda, bichuṛi gandha cahun diśa: guñjana jhanana nāda pañcama pūrata sabahu bana-bhuwa.

Rati-pati bhaja juwaka-juwatī, nācata gāwata hiṇḍola māti, Gowinda-maṅgala Tānasena gāyau rī.

(*The Advent of Spring*)

Spring is come—the King of Seasons, the beautiful, the joyful, the pleasing: in all bowers and gardens the bee hums on each flower, and the cuckoo calls out its notes in the Panchama *key and makes all men and women intoxicated with joy.*

Flowers bloom in the woods fragrant and heart-ravishing— chamelī, bakul, gandha-rāj, belā, motiyā *and the rose.*

The breeze blows soft, spreading the perfume on all sides: the hum of bees, all joyful noises, the notes of the cuckoo—these fill all the woodlands.

Young men and young women worship the God of Love, and

they dance and sing, abandoning themselves to the swing-festival: and Tānaṣena has sung of the praises of Govinda (of the sports of Kṛṣṇa in Brindāban).

[8] Rāga Malhāra. Tāla Cautāla.

Bādara āyau rī lāla Piyā bina lāgai ḍara pāwana.

eka to andherī kārī, bijurī cawankata, umaḍa ghumaḍa barakhāwana.

jaba-ten Piyā para-deśa gawanna kīnau, taba-ten biraha bhayau mo tana-tāwana.

Sāwana āyau ata jhara lāwata: Tānasena-prabhu na āyai mana-bhāwana.

(*Separation in the Rains*)

Ah, the Rain-clouds have come, but without my darling Beloved I feel so frightened, O.

It is black darkness; the lightning flashes, and the rain comes in torrents with the rolling clouds overcasting.

From the time that my Love departed for a far land, his separation has become like a consuming heat for my body.

The month of Śrāvaṇa is come, it has brought here the drip of the rains: but Tāṇasena's Lord, He that pleases the heart, has not come.

[9] Rāgiṇī Bihāga. Tāla Cautāla.

Sāīn, Tūn na āwai āja, ādhī rāta (āndhī rāta), mājha mājha siṃhanī jagāwai siṃha kānana pukāra.

candana ghasata ghasata ghasa gaye nakha mere, bāsanā na pūrata māga-ko nihāra.

dhika janama mere, jaga-men jīwana mere bimukha lagāwai Nātha pakari beṇu bāra bāra.

haun jana dīna ati, nayanahu bāri bahai, Tānasena antara-bāṇī dhurupada pukāra.

(*Separation: a Prayer*)

My Lord, Thou dost not come to-night: it is mid-night (or dark is the night), and at times the lion makes the lioness awake by his roar in the forest.

My finger-nails have become rubbed off, rubbing over and over again the sandal-wood (making a perfume paste for Thy coming); my desire is not fulfilled, looking and looking for Thee in the road.

Fie, O fie upon my birth: my Lord has made my life on earth come to naught by seizing (and playing on) His flute again and again.

I am a most miserable person, tears flow from my eyes: this Dhrūpad utters forth the heart's message of *Tānasena.*

[10] Rāga Bilāwalī. Tāla Cautāla.

tana-kī tāpa taba hī miṭaigī merī, jaba Pyāre-kau driṣṭi-bhara dekhau*n*gī.

jaba darasa pāū*n* Prāṇa-prītama-kau, janama jītawa suphala apanau likhāū*n*gī.

aṣṭa-jāma mohi-kau dhyāna rahata wā-kau, ālī-kau le bheṭau*n*gī.

Tānasena Prabhu koū āna milāwai, tā-ke pāwana sīsa ṭekāū*n*gī.

(*Yearning*)

The fever of my body will cool only when I shall gaze on my Beloved, to the satiety of my eyes.

I shall describe my life and my sojourn as having borne good fruit when I shall have a sight of Him who is the most beloved of my heart.

All the eight quarters of the day and night there is in me the thought of Him: taking my girl-friends with me I shall go to meet Him.

Tānasena (says): should anyone bring my Lord (to me) and make me meet Him, I shall touch his feet with my head.

[Note.—In the above transcriptions, it is to be noted that an Italic *n* nasalises the preceding vowel; *ś* is pronounced like dental *s*, *ṇ* and *ṃ* (*anusvāra*) like ordinary *n*; and *ṣ* when intervocal has been written *ḳh*, following the old Hindi pronunciation. The letter *c*, it is to be noted, has always the value of the English *ch*, and never of *ḳ*. The letter *ṛ* is the so-called cerebral *ṛ* (=*ḍ* between vowels).]

Sir P. C. Ray, the Man and His Work

By F. G. Donnan (London).

It gives me the greatest pleasure to add my testimony to the many others that will be offered on this occasion to the personality and work of Professor Sir Prafulla Chandra Ray.

It was about eleven years ago that I first had the privilege of meeting him. He was on a visit to England and had come to see my laboratory at University College and some of his friends and former pupils who were researching there at that time (Bhatnagar, Ghosh, and Mukherjee). Did he arrive with much ceremony and a flourish of trumpets? No! I found it extremely difficult to know when he had arrived. The extreme modesty of the man was amazing. Here was the Father of Modern Chemistry in India in my laboratory, and yet one scarcely knew he was there at all.

I noticed how he was revered by his old pupils. But not only revered—beloved also. Here was a man who, through the personal example of a life devoted to science and to the care and teaching of his disciples, could inspire in them the deepest reverence and affection. I found then and afterwards that the words modesty and devotion could best describe the personality of Sir P. C. Ray. From the great Buddha onwards through the stream of time, these qualities of mind and spirit have ever been the characteristics of the great leaders of Indian thought and Indian ideals. They have shone with conscious and serene brightness throughout the life and work of Sir P. C. Ray.

I used no idle words of conventional flattery when I called him the Father of Modern Chemistry in India. Perhaps I should have called him simply the Father of Indian Chemical Science. It was he who first devoted himself to a life of scientific research on chemical problems. By his teaching and his example he has pro-

duced a great school of chemical research in India. His pupils occupy distinguished posts, Professorial and other, throughout his native land. When they have come to me in London, I have always found them to be men of high intelligence and enthusiasm for scientific research. They were infused by the spirit of their Master in India, and were determined to carry on the great work which he had begun. Nobly have they done so. India now ranks high amongst the nations of the world which contribute importantly to the advance of science. It would be difficult to overestimate the part which the work and influence of Sir P. C. Ray has played in this splendid development.

I shall not make any attempt to describe or discuss his personal contributions to chemical science. Others more expert than I will do that. Sir P. C. Ray, however, has been throughout his life no narrow laboratory specialist. He has shown by his writings that he is a widely-read scholar in the history of science and the history of chemistry in India. He has, through his energy and practical ability, founded and directed an important chemical manufacturing Company in Bengal. His ideals have always been hard work and practical good in the service of his country. Though devoted to the cause of pure science, he has never been the unpractical dreamer in the clouds. But he has never asked much for himself, living always a life of Spartan simplicity and frugality—a Saint Francis of Indian Science. I hope that future ages will cherish his name as one of the band of self-denying and devoted men who have revived and handed on the flame that once burned so brightly in India, the search for truth and the hidden mysteries of things.

Some Pre-Linnaean Writers on Indian Zoology

By B. Prashad (Calcutta).

In the selection of a subject for my contribution to the projected volume in honour of Sir P. C. Ray's 70th Birthday I have been influenced by his well-known publication "The History of Hindu Chemistry." Dr. F. H. Gravely in his Presidential Address (9) to the Zoology Section of the Eighth Session of the Indian Science Congress gave a very useful summary of the history of Indian Zoology, but the Pre-Linnaean writers are not considered in detail in this Address; in the present contribution I have attempted to supply this deficiency.

The general references to animals and animal products of the Orient in the Old Testament have been discussed by Gravely and need no further reference.

The earlier biological work of the Hindus is summarized by Nordenskiold (18) as follows: "The civilized peoples of eastern Asia, the Hindus and Chinese, have likewise contributed very little of importance to the development of biology." This is a very misleading statement, for as Seal (24)[1] has discussed at length, Charaka, Prasatapada, Susruta, Sankara and above all Umasvati classified animals on a more or less rational basis. Umasvati's classification of the animals is based on the number of senses possessed by the different animals, and his classification, though by no means up to the modern standards of systematic Zoology, is in no way inferior to that of Aristotle, Pliny or Gesner. The anatomical accounts of the earlier Hindu writers, though permeated with fanciful ideas about the numbers and functions

1 For further references to Hindu writers on Zoology see Gravely (9) and Annandale, N.—*Journ. Bombay Nat. Hist. Soc.*, XXIX, pp. 633-634 (1923).

of the organs, are, considering the times, far in advance of what was known at the time in Europe about the anatomy and physiology of animals. They were often based on dissections and a careful study of the animals themselves. In passing it may be noted that the exact dates of the works of the authors referred to above, are still a matter for investigation.

Though chronologically of a later date, the contributions of the Moghul emperors to our knowledge of the biology of the Indian animals may be next considered. The period begins with Babur's victory at Panipat in 1526 A.D. and extends to 1707 A.D., the year of death of Aurangzeb, the last of the Great Moghul emperors of India. The six Moghul emperors, Babur, Humayun, Akbar, Jehangir, Shah Jehan and Aurangzeb were all keen naturalists, and the memoirs of these emperors, as also the historical works dealing with their reigns, are full of references to animals of India. These accounts, though mainly confined to the vertebrates, are of interest in connection with the distribution, numbers, habits, methods of hunting, etc. of different animals. The Moghul emperors in addition to having extensive game preserves, maintained Royal Menageries in which "Animals of all kinds from Persia, Turkestan, Kashmir, whether game or other" were kept for "the wonderment of beholders." Sir Lucas King (14) in his revised and annotated translation of the Memoirs of Babur gave the scientific names of the animals described in the work, and a very valuable and critical account of the animals mentioned was recently published by Salim A. Ali (2). A short article on the identification of the fishes mentioned in these memoirs has also been published by S. L. Hora (11).

In a review of the European writers on biological subjects we have to start with the Greek philosophers, and Aristotle naturally is the first author to be considered in this connection.

Aristotle (3) was a famous Greek philosopher and naturalist born at Stagira in 234 B.C. In his writings about 500 species of animals, both vertebrates and invertebrates, have been recognised. The animals mentioned are mainly from Greece and the surrounding seas, but he also included accounts of several exotic

forms mainly from the writings of earlier authors, though it has been stated that Alexander the Great used to send him material for investigation from the countries he conquered; in these accounts we find mention of such Indian forms as the elephant, the lion, and several species of birds.

Almost three centuries passed before the second outstanding figure, Caius Plinius Secundus (A.D. 23-79), also known as the Naturalist Pliny, appeared. Pliny was born at Como in North Italy, and he left in addition to a large number of his works which have disappeared, the manuscript of a really interesting *Historia naturalis* (19). In the preparation of this work, Pliny consulted over 2,000 works of the earlier writers and the result is an encyclopedia of all that was known about the animals of the different parts of the world. His account of the elephant, which curiously is listed first amongst the animals, though fanciful and inaccurate, is particularly interesting, and is quoted below:—

" Amongst land-animals the elephant is the largest and the one whose intelligence comes nearest that of man, for he understands the language of the country, obeys commands, has a memory for training, takes delight in love and honour, and also possesses a rare thing even amongst men—honesty, self control and sense of justice.............." He also gave a fairly detailed account of its habits, its mating, the methods adopted for its taming, etc. He also referred to several other Indian animals, and in spite of his account being full of most fantastic fables, he can rightly be styled as the first writer of importance on the Indian Fauna.

Zoology was almost a forgotten science till the beginning of the sixteenth century, when the "outstanding product of the New Birth of Zoology" Conrad Gesner or Gessner (1516-1565) published his works. Gesner had studied medicine, philosophy etc. at Paris, Montpellier and Basle, and travelled fairly extensively in Central Europe. Though he died at the early age of 49, he was able to finish his famous *Historia animalium* (8), a well illustrated work in four large folios of nearly 3,500 pages, in which he

classified animals on the Aristotelean plan. The alphabetical arrangement and careful preparation of the work are on a model that is extraordinary for the times, but the most original contribution of Gesner to Science was his introduction of illustrations as an aid to the study of Zoology. Every description is followed by an illustration, and, fanciful though a great many of his figures are, he spared neither trouble nor expense to secure accurate illustrations of the animals. According to the modern standards his classification of animals is very faulty. In the first part he included viviparous and oviparous quadrupeds, in the second birds, the third is devoted to fishes and in the fourth, which was a posthumous work, are described the reptiles and insects.

Ulisse Aldrovandi (1522-1605) followed Gesner, and was probably one of his pupils. He was born at Bologna, and was trained for commercial pursuits in the earlier years of his life. He later studied medicine and became a professor of Pharmacology at Bologna in 1560. All his fortune was spent in collecting natural history objects and he employed the best available artists for preparing illustrations of his collections. His collected works on natural history consist of fourteen large folio volumes; only 4 dealing with birds were published during his life-time, while the remainder on other animal groups, plants and stones were published after his death. Aldrovandi's work *Opera Omnia* (1) is modelled on that of Gesner, but as he lived longer and worked under more favourable conditions he was able to deal with the subject more precisely and in greater detail. His classification of the animals is distinctly more rational than that of Gesner. He paid more attention to anatomy, particularly the osteology of the animals. He was also able to record a larger number of extra-European and so far unknown forms. His work is a definite contribution to our knowledge of biology and exercised a powerful influence on the Zoological work of later authors.

Considering the times, the works (22,4,5) of Gulielmus Rondeletius (1507-66), who has been styled as the "grandfather of modern Ichthyology" and of Pierre Belon (1517-64) on fishes, are of exceptional merit and may be mentioned here. The latter

author was also a famous ornithologist and his contributions to comparative anatomy are particularly valuable.

John Ray (1628-1705), the famous English Naturalist in whose honour the Ray Society of London was founded, was born at Black Notely in Essex. He studied at Cambridge and later became a lecturer on Greek and Mathematics. He afterwards became a companion and co-worker of Francis Willughby, a wealthy English squire devoted to natural history, and it is almost impossible to separate the work of these two workers. There can be no doubt, however, that the chief author of the Zoological part even in the edition of F. Willughby's Ornithology was Ray. The main work of Ray (20) was *Synopsis Methodica Animalium, Quadrupedum et Serpentini generis, etc.* (1693). This publication contains many references to Indian animals and provided Linnaeus with a great deal of the material for the preparation of his *Systema Naturae* (17). To judge Ray's work as a systematist by the modern standards would be hardly fair; though it can not be compared to the later and well-known system of Linnaeus, there can be no question that Ray's work marked an extraordinary advance, and he was, in comparison with his predecessors, very precise in realising differences between genera and species. Several of his larger groups are natural, in the best sense of the word, but a number of his sub-divisions, as for example, those suggested for the mammals based on claws and nails, are highly artificial.

A passing reference may also be included here to the *Historia Naturalis* (12) of John Johnstone (1603-1675) and *Amoenitatum exoticarum, etc.* (13) of Engelbert Kaempfer (1651-1716) in which Indian and exotic animals are treated at some length.

Another worker of this time of very great importance from the historical standpoint was Albert Seba (1665-1716). He was a wealthy Dutchman who assembled a very extensive collection of natural history objects. His private museum was later purchased by Peter the Great of Russia, and removed to St. Petersburg. His work, generally cited as the *Thesaurus* (25) which consists of four elephant folio volumes, was in part, published after his death.

The *Thesaurus* was printed in two editions—a Latin-Dutch and a Latin-French edition—and a re-issue of Guerin's rare edition of this work was later published under Cuvier's supervision. In this edition to which several noted Zoologists, such as Boerhave, Artedi, Mausset, etc., contributed, the plates of the original edition were reproduced. Seba's work, though full of mistakes and fanciful ideas about the classification of animals, is a mine of information, and supplied Linnaeus with a great deal of material for his monumental work on the systematic arrangement of animals. It may be remarked here that this work contains descriptive accounts and fairly recognisable figures of a large number of Indian and Ceylonese animals.

In the following paragraphs I propose considering together several authors who, though chronologically belonging to different periods, specialised in Conchology, and whose works are of special importance in connection with our studies of Indian molluscs.

Martin Lister (*Ca.* 1638-1712) was an English naturalist and a physician born at Radclife, near Buckingham. He was educated at Cambridge and was elected a Fellow of the Royal Society of London in 1671. He contributed numerous articles on natural history, medicine, etc. to the *Philosophical Transactions of the Royal Society, London,* but the works (15, 16) with which we are concerned here are *Historiae sive Synopsis methodicae Conchyliorum, etc.* (1685-97) *and Conchyliorum bivalvium* (1696). Lister was the first conchologist of decided eminence, and his anatomical works show how clearly he realized that a knowledge of the structure of the animals was the only sure foundation on which to base the classification of these forms. He carefully studied "the habits, instincts, and peculiarities of snail and shell, and was at the same time zealous to acquire an extensive and accurate knowledge of species." His *Historiae*, as published, consists mainly of illustrations of the shells, but his plan, which, owing to ill health, was not fulfilled, was to describe the anatomy of every family or genus and thus complete his account of the mollusca.

Filippo Buonanni (1638-1725) was an Italian Jesuit, "with attainments and natural talents which, though respectable, certainly do not raise him above the level of the age." Buonanni's work *Recreatio mentis et oculi, etc.* (6) published in 1861, "was probably intended as a book of luxury exhibiting in plates whatever amongst shells might please the eye or refocate the unoccupied mind." He described or figured almost 600 species of shells, but his anatomical knowledge was even inferior to that of Aristotle.

George Eberhard Rumpf (1627-1702) was a talented trader and Dutch officer at Amboina. He studied the natural history of Amboina and the Moluccas with great care, and his *D'Amboinsche Rariteitkamer* (1705) is a very valuable work of reference (23). He has rightly been termed as "Plinius Indicus" and his work is of importance not only as record of the very large number of new species from the area, with descriptions and illustrations which enable workers to recognize these forms with tolerable surety, but his systematic classification of the molluscs is a distinct advance on the works of Lister, Buonnani, and other workers.

Niccolo Gualtieri (1688-1747) was a Florentine doctor and a lecturer at Pisa. His *Index Testarum Conchyliorum, etc.* (1742) is a work (10) of exceptional importance. The descriptions of the shells are fairly accurate and the illustrations are carefully executed. His classification also is more rational, and in general this work may be described as superior to any published to date.

The work of Dezallier D'Argenville (1680-1765) which appeared in several editions, the final of which (7) is generally styled as *La Conchyliologie* (1780), is not of any special interest, but a reference is necessary to the beautifully executed *Auslesne Schnecken, etc.* (1758) published by the Danish author, Franz Michael Regenfuss (21). In this work the descriptions are printed in German and French in parallel columns and the coloured illustrations deserve special commendation.

The above review brings us to the time when *Systema Naturae* (17) the great systematic work of Linnaeus, which is accepted as the starting point for all taxonomic work, appeared. In this work

"Nature's three kingdoms are presented divided into classes, orders, genera and species," and adopting Ray's theory Linnaeus enumerated "as many species as have been created from the very beginning; the individual creatures are reproduced from eggs, and each egg produces a progeny in all respects like the parents." Linnaeus spent his whole life working out the above-mentioned natural system of classification and his greatest service to Science was the evolving of a binary nomenclature for the different species.

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Magnetism and Chemistry

By S. S. Bhatnagar (Lahore).

The influence of electricity on chemical reactions and the reverse process, namely the manifestation of energy in the form of electricity during chemical change, gave birth to the important science of Electrochemistry. Thermochemistry owes its origin similarly to the discovery of the influence of temperature on chemical reactions and to the phenomena of the production or abstraction of heat during these processes.

It is only during recent years that investigations have been carried out which definitely establish[1] that magnetism also can influence chemical change and that substances like the magnetic oxide of iron and manganese arsenite exhibiting distinct magnetism can be actually made in the laboratory. Although Faraday and Curie early established the Pan-magnetism of matter, it is only after the great discovery of the electronic structure of matter that the magnetic properties could be successfully correlated with atomic and molecular structures. The word magneto-chemistry is, therefore, not so familiar as electro-, thermo- or photo-chemistry although Wedekind published a book bearing the name "Magneto-chemie" long time ago.

From a persual of the behaviour of elements in the periodic table it is evident that the magnetic property of the element does not increase with the atomic weight, but varies periodically with it.[2] According to the electronic constitution of matter, the atoms consist of positive nuclei and electrons revolving round them. These revolving electrons may be considered equivalent to a circuit carrying an electric current and they would thus exert magnetic force in the neighbourhood. Thus the magnetism of molecules and atoms is explained by the revolving electrons, the radius of

the orbits as well as the plane of the orbits. The first theory which satisfied the quantitative requirements with success was due to Langevin.[3] Various modifications and extensions of it on quantum theory and wave mechanics have been described by Honda,[4] Weiss,[5] Pauling,[6] Van Vleck,[7] Hartree[8] and Slater.[9] The important results may be summarised as follows :—

Diamagnetics :—

(*a*) The elements in the zero group are all diamagnetic.

(*b*) The diamagnetic susceptibility has a tendency to increase with atomic number. This is particularly evident from the values for chlorine, bromine, iodine, sulphur, selenium, tellurium, zinc, cadmium, mercury, copper, silver and gold, the only anomalous series being the P - Bi series, where the experimental values are known to be influenced by impurities.

(*c*) The values of diamagnetic susceptibilities for Bi and Sb are abnormally high though they do not fall out of the general range.

(*d*) The case of caesium is of particular interest as it is diamagnetic as opposed to lithium, sodium and potassium. This is perhaps due to the larger number of electrons it possesses, which more than overbalance the residual paramagnetism due to the valency electrons.

(e) The diamagnetism is not influenced by temperature, but there are a number of elements where this rule does not hold—some elements increasing their susceptibilities on heating, others decreasing. This aspect of diamagnetism is being extensively investigated and deserves special study. The susceptibilities which have been discussed above refer to the elemental state of matter and not to the atomic state. It is possible that in the building up of the element in mass, electronic configurations consist of paramagnetic as well as diamagnetic types and that the influence which is observable in the case of elements is attributable entirely to that part which may be paramagnetic in configuration.

The influence of temperature in the case of diamagnetic

molecules and compounds is also important for similar reasons and will be referred to more fully later on.

An important outcome of the investigations on the magnetic properties of the elements was the discovery of the fact that the values of magnetic susceptibilities are different in different allotropic forms. This line of work has acquired special importance as a result of revival in interest in the magnecrystallisation effect first described by Faraday in 1845. Some of the results obtained are shown in the table below:

Element		Author
Sulphur.		
Rhombic	$0{\cdot}487 \times 10^{-6}$	Bhatnagar and Mathur.
Monoclinic	$0{\cdot}462 \times 10^{-6}$	Do.
Colloidal	$0{\cdot}510 \times 10^{-6}$	Owen
Plastic	$0{\cdot}4$ (approx) $\times 10^{-6}$	Bhatnagar and Mathur.
Phosphorus.		
Yellow	$0{\cdot}84 \times 10^{-6}$	Curie
Red	$0{\cdot}66 \times 10^{-6}$	Do.
Tin.		
Grey	$0{\cdot}35 \times 10^{-6}$	Honda
White	$+0{\cdot}025 \times 10^{-6}$	Honda and Owen.
Carbon.		
Graphite	$3{\cdot}5 \times 10^{-6}$	Owen
Diamond	$0{\cdot}49 \times 10^{-6}$	Honda and Owen.
Lamp Black	$0{\cdot}36\text{-}0{\cdot}53 \times 10^{-6}$	Paramasivan
Gas Carbon	$2{\cdot}0 \times 10^{-6}$	Honda
Oxygen.		
O_2	$104{\cdot}7 \times 10^{-6}$	Curie
O_3	...	...

Paramagnetics:—

The following general conclusions have been arrived at from a study of the paramagnetic elements in the periodic table:—

1. The alkali metals with the exception of caesium are all paramagnetic.

2. Excepting in a few cases the value of the susceptibility decreases with temperature and a modified Curie law is obeyed.

3. Platinum, neodymium, cerium, praseodymium groups follow also the modified Curie law.

Ferromagnetics :—

Although the ferromagnetics constitute an important class of metals, this property is restricted only to a class of elements in the 8th group of the periodic table. It is also noted that at a critical temperature varying with the element under examination, the ferromagnetism lapses into paramagnetism and the susceptibility varies with the field strength. Much interest is attached to this property particularly when one notices that small impurities profoundly alter the character of the ferromagnetic material, particularly with respect to retentivity and hardness, and there is a lot of material for the future investigator in this branch of magneto-chemistry.

Magnetism and Valency :—

(*a*) *Case of odd molecules*: G. N. Lewis[10] considers the pairing of electrons, which is certainly one of the most important factors in chemical combination, as nothing but some sort of conjugation of two elementary magnets of such character as to eliminate naturally their magnetic moment. The highest degree of unsaturation, according to him, is represented by an odd molecule. Thus the odd molecule would enter into chemical combination most readily. It is in this connection that the possibility of magnetism being one of the factors in valency seems to suggest itself. It is significant that the number of odd molecules is comparatively much smaller than those of even numbers. As the tendency of electrons is to occur in symmetrical groups or in pairs, it is difficult to obtain many substances of odd molecular number. It is interesting to note that almost all odd molecules are paramagnetic.

CuO (odd)	+1·35
Cu_2O (even)	−0·34
$CuCl_2$ (odd)	+8·77
CuCl (even)	−0·41
$CuBr_2$ (odd)	+2·71
CuBr (even)	−0·34
BiO_2 (odd)	+1·55
Bi_2O_3 (even)	−0·26

The recent accurate work of Sone[11] also shows clearly that while N_2, N_2O, N_2O_3, N_2O_4 liquid and N_2O_5 solid are all diamagentic, the two odd molecules NO_2 and NO in the family are paramagnetic.

(*b*) *Case of simple ions :* As far as the mono-atomic ions are concerned, the relation of their magnetic properties to electronic structure is at least qualitatively clear. All ions which are composed of complete electronic groups for example K^{+}_{18}, Ca^{++}_{18}, F^{-}_{10}, I^{-}_{54}, Cl^{-}_{18} having inert gas configurations and Cu^{++}_{28} Zn^{++}_{28}, Cd^{++}_{46} with Effective Atomic Number eight units less than the nearest inert gas configuration are diamagnetic. Paramagnetism is only found among the ions of the transitional elements in the wider sense and the rare earth metals and their ions all contain incomplete electronic groups. For the rare earth metals from lanthanum (atomic number 57) to luticinum (atomic number 71) and for the element of the first long period from scandium (atomic number 21) to copper (atomic number 29) this conclusion is completely established.

The ions of the intervening elements in which the fourth quantum group contains more than 18 and less than 32 electrons are paramagnetic. These results have been derived from experimental work on the magnetic properties of solutions of these salts in various solvents and the solid salts themselves. From these results it is clear that the magnetic moment of the ions primarily depends upon the number of electrons and not on the nuclear charge and that the Bohr magneton exists as a fundamental physical unit. The structure of the ions of the transition elements

presents peculiarities and the magnetic theory has to be suitably modified to account for their behaviour, perhaps in these cases there is an equilibrium between two forms of ions.

The rare earth metals constitute a group of fundamental importance from the magneto-chemical standpoint. The immense difficulties involved in their purification make the task of experimentation rather tedious. The mean values obtained by Cabrera[12] and Stefan Mayer[13] have established the relationship that the magnetic moments are zero for ions with 54 (La^{+++}, Ce^{+++}) and 68 (Lu^{+++}, Hf^{++++}) electrons. These ions have the complete fourth quantum group of 18 and 32 electrons and they are capable of forming inert gas configurations. Between the Effective Atomic Number 54 and 68 we have the ions in which the grouplets of $6 \times 4_{43}$ and $8 \times 4_{44}$ are being built up.

(c) *Case of Werner's Co-ordination Compounds and Complex Molecules*:—Following the concepts of Sidgwick, Welo and Baudisch[14] have given the lead in elucidating the magnetic properties of the co-ordination compounds. They have brought into prominence the fact that the complex compounds, whose Effective Atomic Number is equal to that of the next higher inert gas, exhibit diamagnetism as they form closed configurationns like that of the latter. They also showed that complex compounds, whose Effective Atomic Number falls short of or increases the inert gas configuration, exhibit paramagnetism. L. C. Jackson[15] disagrees with this rule.

D. M. Bose[16] of Calcutta has gone a step forward and assumes that the magnetic moment of complex salts expressed in terms of Bohr's magnetons are mostly proportional to the difference between their Effective Atomic and the atomic number of the next higher inert gas. Bose has further shown that $Z' = N - E + 2p$, where N = atomic number of the co-ordinating atom, E = its primary valency in the given compound and $p = 4$, 6 etc. according as the compound is four-fold, six-fold, etc. For example in the ferrous compound $K_4[Fe(CN)_6]\,3H_2O$, $Z = 26 - 2 + 2 \times 6 = 36$, while in the case of he four-fold compounds of copper $Cu(NH_3)_4(NO_3)_2$, $Z = 29 - 2 + 2 \times 4 = 35$. The first one is therefore diamagnetic

and the second paramagnetic. Bose has further improved his rule by taking into consideration the distribution of electrons among the M_{32} and M_{33} sub-group in the elements and ions of the transition group and according to his latest views on the subject, $M_{33}+N_{11}-M_{32}=n$, where M_{33}, N_{11} etc. represent the number of electrons in the sub-group and n = number of Bohr's magnetons.

Cabrera[17] has put forward a scheme in which the fundamental principles of the tendency of external electrons to ape the next higher inert gas structure has been entirely ignored. Cabrera has made use of the scheme put forward by Fowler, who proposed that electrons outside the K and L levels of a six-fold co-ordinating atom have a tendency to be distributed in the groups $8+6+12$. The first 8 electrons are those occupying the M_{11}, M_{21} and M_{22} sub-groups of the atom, the next 6 tend to collect into the M_{33} sub-group and remaining 12 electrons are shared by the central atom and the group surrounding it. Cabrera's scheme, briefly speaking, implies that paramagnetism in complex ions develops when any sub-group in the main quantum groups of the central atom does not contain its full quota of electrons. Consequently a completed or vacant sub-group develops diamagnetic property.

P. Ray[18] has recently examined in a very thorough manner the physical and chemical properties of the complex compounds and he has divided these compounds into two main classes, which he calls strong or perfect and weak or imperfect complexes. It is to the first of these compounds that the scheme of electron distribution by Sidgwick is applicable. Ray assuming with Ladenburg that it is only the incompleted groups that contribute to the magnetic moment has drawn up a scheme of electron distribution in case of simple compounds. He further assumes that an odd electron in the M_{33} sub-group is very mobile, especially at the commencement of the formation of the groups, and readily acts as a valency electron, whereas every two electrons tend to produce a more or less stable complexity, the stability of a group on the whole increasing with the number of electrons in it. The problem is by no means closed and the results of further investigations are awaited.

with interest. A new avenue of research has been opened which has immense possibilities.

Chemical Constitution and Magnetic Properties :—

Investigations under this head can be placed under three distinct classes :—

(a) Chemical constitution in relation to Pascal's work.[19]

(b) Chemical constitution as evidenced by the magnetic optical rotation method after the manner of W. H. Perkin and others.[20]

(c) Chemical constitution as revealed by the magnetic birefringence method.

As regards (a) it is well-known that Pascal measured the susceptibilities of a great many organic compounds. He established the important point that diamagnetic atoms combine to give diamagnetic molecules and that to a first approximation the diamagnetic properties are additive. Paramagnetic atoms frequently lose their paramagnetic character on combination and ferromagnetics with the exception of manganese generally form non-ferromagnetic compounds. With the methods of measurements available to Pascal, the conclusions arrived at could not be excelled. It has however been shown by the author and his collaborators by the aid of their magnetic interference balance that Pascal's results hold only to a first approximation and that diamagnetism is susceptible to constitutive effects and that even such cases as geometric isomers, polymers and position isomers exhibit real difference in their values of susceptibilities. Crystal structure also has influence on magnetic susceptibility.

Regarding (b) the extensive work of W. H. Perkin, which is so well-known, fully established the usefulness of the Faraday effect as a weapon for yielding conclusive evidence on constitutional matters in organic chemistry.

(c) In 1907 Cotton and Mouton[21] found that when light traverses a pure liquid placed in a strong magnetic field in a direction transverse to the lines of force as against parallel, the liquid exhibits a feeble birefringence. This effect was noticed previously by Majorana[22] in the case of colloidal iron oxide. Cotton and

Mouton first saw the phenomena most conspicuously in nitrobenzene. In Cotton's laboratory and in the laboratories of Sir C.V. Raman[23], this effect has been very carefully investigated and it has now been established that all isotropic substances possess this property. In the laboratory of the author this property is also being investigated and it has been shown that liquid crystals like p-azoxyanisole show double refraction even greater than nitrobenzene. This property promises an interesting field of enquiry in magnetochemistry. Particularly remarkable is the magnitude of the effect in aromatic and aliphatic compounds. As a rule this effect is more prominent in the aromatic compounds as opposed to the aliphatic compounds. It is significant that the influence of temperature on diamagnetism is also more pronounced in the case of aromatic compounds as compared to the aliphatic ones. Also for compounds having the same composition, it is significant to note that the aromatic compounds have a much greater tendency to form crystals than the alphatic ones and it appears that this aspect of magneto-chemistry will throw much light on the magne-crystalline effect and the velocity of crystallisation and nucleus formation.

Magnetism and Chemical Reactions :—

It will not be out of place to give a small space here to the influence of magnetism on chemical reactions. As early as 1881 Ramsen[24] observed that magnetism had a remarkable action on the deposition of copper from solution of its salts on an iron plate. In 1886 Nichols[25] further investigated the action of acids on iron in a magnetic field. In 1887 H.A. Rowland and Louis Bell read a paper at the Manchester Meeting of the British Association on the protection of iron from the chemical action of hydrochloric acid in a magnetic field. Loeb,[26] and later Wolff[27] obtained negative results on the influence of magnetic field on the oxidation and reduction of iron salts, while Jahr[28] observed that a photographic plate immersed in a developer or even in distilled water is effected when brought near the pole of the electromagnet. Theoretical reasons for a positive effect have been advanced by Alexander de Hemptenine[29] and Weigle[30] as well as Sir J. J. Thomson.

In the laboratories of the author, Mathur and Kapur[31] have shown that the results of chemical action in magnetic fields can be expressed symbolically as follows:—

$\Sigma \chi M_f > \Sigma \chi M_i$ the rate of reaction is accelerated by the field. ... ... (1)

and when

$\Sigma \chi M_f < \Sigma \chi M_i$ the rate of reaction is retarded by the field. ... ... (2)

while with ...

$\Sigma \chi M_f = \Sigma \chi M_i$ no change within and without the field. ... ... (3)

where $\Sigma \chi M_f$ = the sum of the molecular susceptibilities of the final products,

and $\Sigma \chi M_i$ = sum of the molecular susceptibilities of the initial substances.

In all the experiments considered so far, the case of reduction of ferric chloride with aluminium stands out as an apparent exception, for in this case $AlCl_3$ is diamagnetic, and as in the case of zinc the reaction is expected to be retarded. Contrary to this, however, the reaction is accelerated. We can, however, say that in the cases where the metal itself is paramagnetic the reaction is accelerated, for both Fe and Al are paramagnetic. Zn is diamagnetic and the reaction is therefore retarded.

The results obtained above are certainly partly due to the mechanical concentration of the paramagnetic products of the reaction and a critical survey of the whole problem presents many points of interest.

Besides the main problems outlined above, problems connected with the nature of magnetic carriers in elements and compounds, the effect of crystalline structure on magnetic properties, the magnetic changes produced when matter converts itself from one phase into the other, the influence of colloidalisation and impurities on magnetism constitute problems of intrinsic interest and importance for the chemist. The time-lag in the Faraday effect in the hands of Beams, Allison and Murphy[32] promises to become

a powerful weapon for chemical analysis and for the detection of isotopes. It is clear that the field of magneto-chemistry is still in its infancy and that the youthful adventurer in this field will find it full of interesting and fundamentally important problems.

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I regret very much that, as I am just on the point of leaving for Canada, I am not able to contribute a suitable article for inclusion in the volume.

I was amongst the earliest batch of pupils of Professor Ray at the Calcutta Presidency College, and remember his stimulating teaching with much gratitude. Sir P. C. Ray has done wonderful work for India, and has been unequalled in the success which he has attained in gathering round him a remarkable band of enthusiastic workers in scientific research. May we have many others to follow his example in this respect !

A. C. Chatterji.

A Human Personality

By M. O. Forster (Bangalore).

As an old friend and admirer of Acharyya Ray, my feelings in contributing to a commemoration volume on his completion of seventy years are not entirely joyous; because they carry me back to a date more than twenty-five years ago when, on the occasion of a periodical visit to England, his physical presence first precipitated itself in my laboratory: and sexagenarians, in common I suspect with septuagenarians, cannot contemplate without a pang the dissolution of so long a cycle.

Naturally his name was already well known to me, and was indeed easily the foremost among his chemical compatriots of which I was aware. The fact that he now stands at the head of an abundant national concourse, preponderatingly his own chemical progeny, is largely due to his genius and enthusiasm: it is one of the principal reasons for this pleasant conspiracy among his friends to unite in doing him honour to-day.

At the time I now recall, his noteworthy researches in the field of nitrogen chemistry were the material introduction; but a more personal bond was our mutual association with Dr. Edward Divers, an eminently delightful character among the major planets in the chemical galaxy of that period. Dr. Divers had retired in 1899 from twenty-six years' distinguished service to the University of Tokyo and, from this oriental affiliation conjoined with his own skill in the chemistry of inorganic nitrogen derivatives, had assisted Acharyya Ray in arranging some of his earlier contributions to the Chemical Society's Transactions. Outstanding among these in its quality of picturesque surprise was the announcement that ammonium nitrite could be sublimed, and that the preliminary vaporisation occurs without dissociation: similarly the benzyl-

ammonium and dibenzylammonium nitrites were also produced in the form of sublimate.

Thereafter, until my coming to this country in 1922, meetings with Acharyya Ray were rare; but happily since then we have been thrown into close association by a joint interest in the Indian Institute of Science, Bangalore, which he has faithfully visited three times a year since 1926, when first elected to the Council as a representative of the Court. It has thus become my good fortune to recognise and esteem the sterling merits for which he is justly venerated among his countrymen, and to perceive the qualities of mind and character by which he has endeared himself to all those in whom the pursuit of chemistry has been their dominating life-interest.

Other admirers, with more intimate knowledge of the circumstances, will pay well deserved tribute to Acharyya Ray as a practical benefactor, whose activities in this region have been fulfilled by an austerity of self-denial that few can imitate. Others will dwell on his auspicious achievements in chemical manufacture and in literature. For my part, I commemorate him as an ardent investigator, an alert-minded spectator of life to whom every branch of mankind's activity presents interesting features, a disputant and thinker of sturdy independence and sub-acid humour: but above all, as a very lovable and sympathetic human personality.

হে আচার্য্য, তোমারে স্মরিতে আমারে যে হইল ফিরিতে
সুদূর কৈশোর তীরে, সবে যবে ফিরে ফিরে
শুনিতাম তপস্যার কথা,
পূত তব চরিত্র বারতা ॥
অপূর্ব্ব সে তব অবদান, জাতির জীবনে নব দান,
অভিনব রসায়ন, খুলে দিল যে অয়ন
শুষ্ক রুক্ষ শিক্ষার মাঝারে, পরিত্রাণ করিলে সবারে ॥
চিতাভস্মে প্রাণ দিলে তুমি, মৃতপ্রায় ছিল জন্মভূমি ;
ওগো "নব ভগীরথ" শঙ্খে তব পেল পথ,
কত শত তরুণ পরাণ, স্বদেশে বিদেশে অভিযান ॥
যে জ্ঞান করিলে বিতরণ, পুরাতন করি আহরণ,
আজ তাই ছাত্র সবে, প্রচার করিছে ভবে,
প্রাচ্যের গৌরব অনুরাগে প্রতীচ্যের আঁখিপুরোভাগে ॥
দেশে দেশে দেশমাতৃকার সকল ব্যথার প্রতীকার।
হে তপস্বী তব পরমায়ু, স্বদেশের চেতনার স্নায়ু,
নবীন জীবনে ভরি' সব অবসাদ হরি,
আগুসার করুক সবায়, প্রাণপূর্ণ দীপ্ত প্রতিভায় ॥
তুমি থাক সারথী সবার, এই মত নিত্য অনিবার,
জীবন সুদীর্ঘ হোক, পেয়োনাক দুঃখশোক,
অজাতশত্রুর মত জয়যাত্রা অব্যাহত
হোক, শেষজীবনের পথ,
হও তুমি পূর্ণমনোরথ ॥

শ্রীপ্রিয়ম্বদা দেবী

Gobioid Fishes of Torrential Streams*

By Sunder Lal Hora (Calcutta).

(Plate I).

In a paper (Hora, 1930) on the 'Ecology, Bionomics and Evolution of the Torrential Fauna' evidence was adduced to show that this fauna has colonized the torrents by means of a step-by-step migration from lower levels, and that in response to the necessities of the new enviroment it has undergone certain structural modifications, which are undoubtedly of the nature of adaptations. It was also indicated that when animals favourably equipped structurally or physiologically enter a new habitat, they become adapted more readily to fresh conditions of existence than those that have to undergo considerable modifications in response to new environmental factors. The present study of the Gobioid fishes of the torrential streams of small oceanic islands lends further support to these views.

It is well known that the freshwater fish fauna of the islands between the greater Sunda Islands and New Guinea as well as of the Andaman Islands is chiefly constituted of marine fishes, which took possession of the available fresh water as invaders from the sea (de Beaufort, 1913; Annandale and Hora, 1925). Of these invaders the Gobioid fishes are of special importance, not only because they constitute a majority of the fish fauna, but also on account of the remarkable physiological adaptability and structural modifications undergone by some of the members of this group.

The Gobies form a large and varied sub-order of fishes, mostly of small size and of carnivorous habits; they are bottom dwelling,

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coastal fishes of tropical and temperate seas, and are found mainly among rocks between tide marks. There are several species that enter rivers, and quite a number of them are restricted to fresh water, especially in the Indo-Australian region. In Indian waters, *Glossogobius giuris* (Ham. Buch.) exhibits a remarkable physiological adaptability as it is found in the seas as well as in rivers, ponds and ditches.

The Gobioid fishes can be divided into two groups according to the nature of the pelvic fins, which are situated in the thoracic region. The first group comprises those species in which the pelvic fins are united to form a rather deep, cup-like sucker, while in the second group the pelvic fins are separate. The sucker enables the fishes to anchor themselves to rocks in tidal zones, whereas the pelvic fins of the second group are used, almost like a pair of hands, for clinging to rocks. It is thus seen that all the Gobies are partially adapted for entering small torrential streams where adhesion to rocks in swift currents is one of the main needs of existence. Further, it is obvious that Gobies with a ventral sucker are more capable of colonizing swift currents than those of the second group. In this communication I shall deal with the fishes of the two types separately.

In dealing with the freshwater fishes of the Andaman Islands Annandale and the present writer (1925) referred to the habits of *Sicyopterus garra* Hora which are closely similar to those of the familiar torrent-inhabiting fishes of the genus *Garra* (Hora, 1921). This fish lives in rapid-running waters where it clings to rocks by means of a ventral sucker and feeds by scraping organic matter, mainly minute algae and small insect larvae, from the surface of rocks to which it adheres. The sucker formed by the pelvic fins (pl. 1., fig. 5) instead of being in the form of a loose, deep cup, is flat and muscular with a strong transverse band of skin binding the two fins and acting as the rim of the sucker anteriorly. The central part of the sucker is united to the body and the margin forms a loose fringe. By the raising of the central part the entire structure is capable of being converted into a strong and powerful sucker. The adhesion is further assisted by the pectoral fins, some of the

inner rays of which are provided with adhesive pads of skin on the ventral surface enabling them to be closely applied to the substratum.

In *Sicyopterus garra* (pl. 1., fig. 4) the mouth is situated on the ventral surface and is bordered by the fringed and pendant lips. The strong and sharp horny pads on the lower jaw assisted by the prominent canine teeth help in scraping off algae and other encrusted food particles from the rocks, while the lips by acting as a screen against swift current help the fish in feeding by preventing the escape of food particles.

In general facies the fish is subcylindrical and well adapted to offer less resistance to the current and to hide in crevices among rocks and stones. The ventral surface is slightly flattened, and in front of the anal opening the scales are somewhat reduced thereby enabling the ventral surface to be closely applied to the substratum.

In most of the Gobies there is a simple natatory bladder, but in *Sicyopterus micrurus* Blkr., of which I have dissected a specimen, the air-bladder is absent. The absence or reduction of the air-bladder in *Sicyopterus*, as in the case of other hill-stream fishes, appears to be due to the ground habit of life adopted by these fishes.

Besides *Sicyopterus*, of which I have studied a species in its natural haunts in the Andamans, there are several genera, such as *Sicydium*, *Sicyopus*, *Microsicydium*, *Stiphonodon* and *Schismatogobius*, which are found in the small, torrential streams of the oceanic islands of the Indo-Australian Archipelago, and which are variously modified in a manner more or less similar to that of *Sicyopterus*. I have examined the available material of these genera in the Zoological Museum at Amsterdam.[1] The abundance and variety of such Gobioid genera in the torrential streams is simply amazing, and there can hardly be any doubt that they have originated from marine ancestors which invaded the fresh

1. I have to offer my sincere thanks to Prof. L. F. de Beaufort for placing this valuable material at my disposal and for presenting the duplicates of several interesting forms, which are now preserved in the collection of the Zoological Survey of India.

waters. Originally adapted for life in the surf line these fishes migrated into streams, and by a gradual modification of the organs of attachment became adapted for life in stronger and stronger currents of the torrents. That this must have been the course of evolution of these genera is also evident from the fact that " in the case of the Gobies which live in deeper water with little or no current, the sucker is but feebly developed and is perhaps more a tactile organ than a sucker" (Kyle, 1926, p. 270). It is clear from the above that the same structure undergoes different modifications under diverse conditions of existence, and that the fundamental object of a modification is to enhance the utility of the structure to the organism concerned in a particular environment.

Most of the freshwater Gobies of the second group belong to the genus *Eleotris* (*sensu lato*). The habits of one of these—*Eleotris* (*Ophiocara*) *ophiocephalus* (Kuhl and v. Hass.) found in the fresh waters of the Andaman Islands—have been described by Annandale and the present writer (1925, p. 34). The shape of its head and its organs of attachment clearly indicate that this fish is not as highly modified for life in swift currents as *Sicyopterus garra*, and if not observed in its natural haunts might be mistaken for a surface fish. The most remarkable species, however, to be dealt with in this section is *Rhiacichthys aspro* (C. & V.) which is greatly modified and highly adapted for life in torrential streams. It is generally found at fairly high altitudes and is known to occur in Java, W. Ceram, Celebes, etc.

In its general facies and build *Rhiacichthys aspro* (pl. I fig. 1) resembles very closely the fishes of the genus *Garra* or the Homalopterid fishes. The dorsal profile is slightly arched, while the ventral surface is flat and horizontal. The head is short, semicircular and greatly depressed; its ventral surface, as also of the body in front of the anal-opening is smooth and devoid of scales. The gill-openings are short and extend to the ventral surface only for a short distance. The mouth is inferior, small and semicircular. The anterior lip is thick and covers the jaw, which is produced into a shovel-like process with a sharp and strong cutting edge. There is a deep groove on the dorsal surface behind

the tip of the snout; it extends on the ventral surface and is continuous with the grooves round the corners of the mouth. This groove probably facilitates respiration when the fish is adhering to rocks. The peculiar lower jaw no doubt helps in scraping off algae and slime from the rocks.

The pectoral fins are broad and fan-shaped and are obliquely inserted on the sides of the fish. A number of the anterior rays are horizontally placed so that when the fish rests on a rock they come in close contact with the substratum and help in adhesion. These rays are provided with adhesive pads of skin on the ventral surface. The pelvic fins (pl. 1 fig. 2) are situated on the ventral surface; each of these is divided into two portions, an anterior with strong rays provided with thick pads of skin and a posterior with the ordinary type of rays, which, I presume from an analogy with other hill-stream fishes, are used for expelling the leakage water from the under side of the fish when it is adhering to rocks and stones (Hora, 1930, p. 260).

The structure of the rays in the pelvic fin (pl. 1 fig. 3) is of special interest. The fin is broad and fan-shaped, and on a superficial examination appears to possess a large number of rays. When it is properly dissected and cleaned, the basal portion of the fin shows that it is composed of six rays only. The first four rays and the anterior portion of the 5th form the adhesive portion of the fin, whereas the vibrating portion of the fin is composed of the 6th ray and the posterior portion of the 5th. The first ray is not segmented and is in the form of a short spine with a double articular surface; it is probably composed of two rays coalesced together throughout their lengths, the line of union being still marked. The second and the third rays are divided into three branches each which appear like simple rays. The fourth ray is composed of 4 branches, whereas the fifth ray possesses a long axis posteriorly from which as many as 15 short and long branches are given off anteriorly. The sixth ray is divided into 8 long branches which are disposed in a fan-shaped manner and appear like the ordinary fin-rays of a fish. Only a short proximal portion of the 2nd to the 5th ray is unsegmented,

whereas the remaining portion of each is articulated throughout. In the case of the 6th ray the segmentation extends almost to the base of the articular surface.

Attention may here be directed to the structure of the rays in the paired fins of the Gastromyzoninae. In *Gastromyzon* and its allies there is only one simple ray, the neighbouring rays, although appearing superficially simple, are in reality forked; the primary branching is retained and each of these is further modified into a structure corresponding to a simple ray. In the case of *Rhiacichthys* this process is carried several stages further, and the resulting modification is remarkable.

In *Rhiacichthys* the eyes are placed dorso-laterally and the air-bladder is absent. The first ray of the anal fin is covered with thick skin especially along its anterior border. When the fish lies flat on the substratum the thickened portion of the anal fin probably helps in adhesion by coming in contact with the rock.

It is clear from the above that with whatever structures the organisms are provided in the beginning they are subjected to continuous moulding by their surroundings during their evolution. Further, it is clear, as has been forcefully advocated by Prof. E. W. MacBride in recent years (1931) that habit plays a great part in the evolution of new forms. Acquisition of new habits depends upon the necessities of the organisms and the opportunities that come in their way. Moreover, it is supported by abundant evidence that a change in the habit of an organism brings about special adaptive modifications in its structure. It should, however, be borne in mind, that the change in habit as well as that in structure is a slow and gradual process; the change in habit is the cause and the change in structure the effect. The phrase 'change in structure' is of wider significance, for I do not believe that new structures arise suddenly and *de novo*. All are evolved, as is clear in the case of the Gobioid fishes discussed above, by the gradual transformation of, the addition to, or the subtraction from something already in existence. In fact, we find in every instance when subjected to a thorough scrutiny that structural modifications

are produced through changes of functions. In short, Dohrn's "Theory of the Change of Functions" seems to have a universal application.

The structural modifications of the Gobioid fishes referred to above are parallel to those found in the Cyprinid, Homalopterid, Sisorid and other hill-stream fishes found all over the world. The similarity of habitats has led to a remarkable similarity of adaptations in organisms of widely different origins. The torrential fauna thus provides an instance of what Annandale and the present writer (1922) have termed 'Communal Convergence' on a vast scale.

The drawings illustrating this paper were made by Mr. R. Bagchi under my supervision. I have to thank him for his excellent and faithful delineations of the material given to him.

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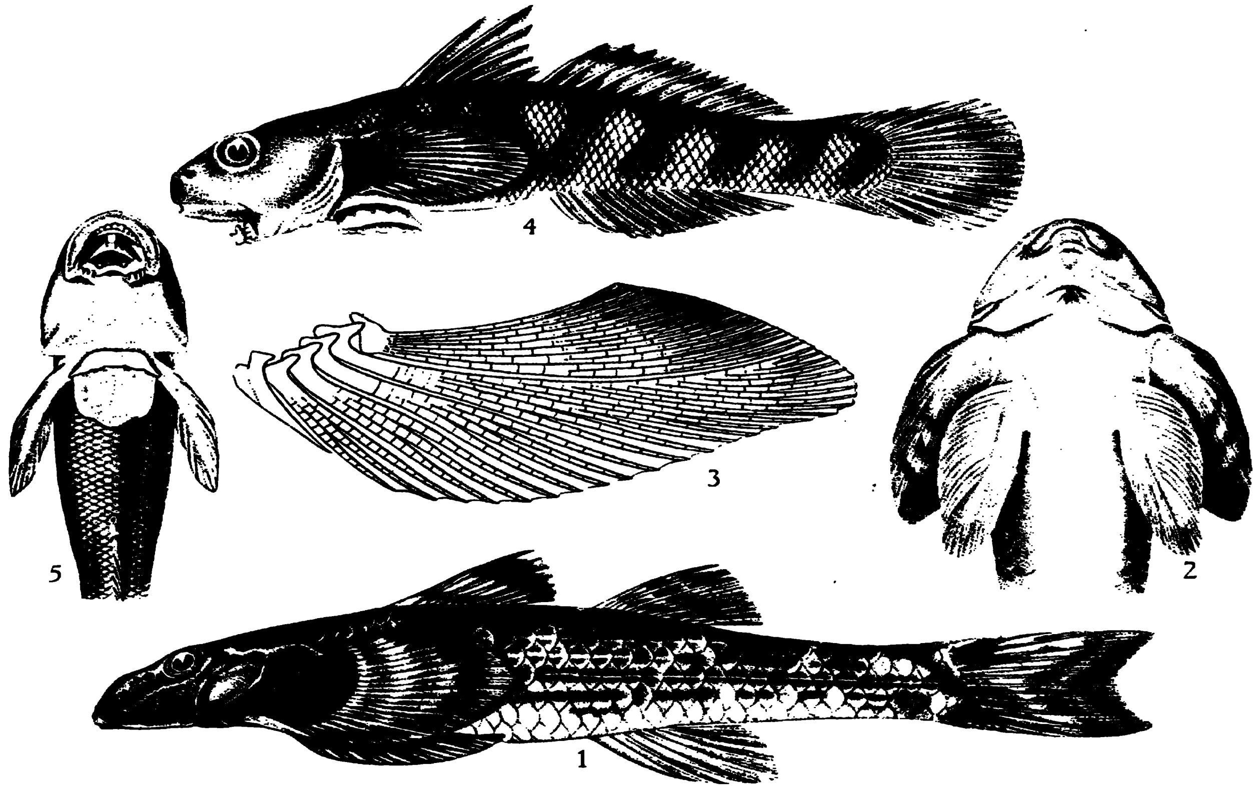

GOBIOID FISHES OF TORRENTIAL STREAMS

R. Bagchi *del.*

The Indian Photo Engraving Co., Cal.

EXPLANATION OF PLATE I.

Rhiacichthys aspro (C. & V.).

Fig. 1.—Lateral view × 1½.

Fig. 2.—Ventral surface of head and anterior part of body × 1½.

Fig. 3.—Ventral fin dissected out and cleaned × 3.

Sicyopterus garra Hora.

Fig. 4.—Lateral view × 3 (after Annandale and Hora, 1925).

Fig. 5.—Ventral surface of head and anterior part of body × 3 (after Annandale and Hora, 1925).

It has been my privilege to be associated with Sir Prafulla Chandra Ray as a member of the Indian Chemical Services Committee and also as Secretary of the Indian Science Congress during the year in which he was the President. It therefore affords me much pleasure to learn that his great services to science are to be recognised on the occasion of his 70th birthday.

The departments of chemistry in the various universities and university colleges in India are now so actively engaged in chemical research that it is difficult to realise the conditions existing when Sir Prafulla first commenced his work at the Presidency College, Calcutta. Fresh from the Edinburgh laboratories and inspired by Crum Brown, he set himself the task not only to advance chemical knowledge with his own researches but also to train his students to do the same. The number of his students now holding high positions is sufficient testimony to his success. In the early days he received little encouragement from outside and only his indomitable courage enabled him to continue his work in an atmosphere, which, even 20 years ago, was unfavourable. I think that when the history of the scientific development of India during the last 40 years comes to be written, it will not be Sir Prafulla's own contributions to science, valuable as they are, which will fill its pages, but rather the great scientific renaissance which his example inspired and which has resulted in the recognition in India, as elsewhere, of the fact that the advancement of knowledge is one of the primary functions of a university. He would desire no higher tribute.

J. L. Simonsen.

The Hindu College and the Reforming Young Bengal

By S. K. De (Dacca).

The history of the Hindu College embodies the history of modern Bengali culture in the second and third quarters of the nineteenth century; but it is somewhat extraordinary that of the names of all the persons who were instrumental in establishing the institution, the name of a foreigner should occupy a prominent place. But perhaps no foreigner in Bengal has ever pursued so remarkable a career as David Hare. Himself a man of limited education, he is gratefully remembered to-day as one of the founders of English education in Bengal. Never directly connected with teaching, nor openly assuming the role of a reformer, he was yet an educator and reformer in the best sense of the terms. Hare affords the remarkable, and perhaps the solitary, instance in Bengal of an individual who without any refinement of education, without high intellectual endowments, without place or power or wealth, acquired and retained a most important and influential position in the history of modern culture in Bengal, simply by a constant and sincere endeavour for unostentatious service.

The other name which is especially associated with that of David Hare in the foundation of the Hindu College is that of Raja Ram Mohun Roy. Ram Mohun Roy incarnates the impulse which led thinking Indians to devise and work for English education, without an exaggerated faith, however, in the foreign and in the external, and without any desire, again, of aggressive antagonism against orthodox conventions irrespective of their merits. In his role as the enlightener of the people, he, more than any other Indian of that day, advocated the necessity of a new departure in education; a new departure in which the literature and

sciences of the West should bring new inspiration and lift the minds of his countrymen from the rigidity of dead habits and traditional forms. In David Hare, on the other hand, the scheme found an eager, active and valuable supporter who had already endeared himself to the people of the land by his large-hearted benevolence and interest in education, and whose energy and practical common sense carried the scheme into maturity and fruition. Hare was neither a Government official nor a Christian missionary but he represents the whole-hearted sympathy which Englishmen of those days felt for their land of adoption. He helped not only in the establishment of the Hindu College but, year after year, he superintended patiently the growth of the institution. Contemporary records are full of references to his quaint figure, dressed in a long blue coat adorned with large brass buttons, moving through the class room or attending the debates of the Academic Association, to his old-fashioned *palanqueen* which was a veritable moving dispensary, as well as to his amiable countenance always beaming at the hovel of the charity boy or at the bedside of the fever-stricken student. It is in the fitness of things that David Hare's mortal remains, which were denied the rites of Christian burial by an impatient orthodoxy, should lie to this day buried under the monument, erected by a people's love to his memory, on the south side of the tank in the College Square and within sight of the College Street.

The facts of David Hare's life are very few and can be told very briefly.[1] Son of a watchmaker in London, who had married an Aberdeen lady, Hare came out to Calcutta in 1800 at the age of twenty-five as a watchmaker; and, after following that profession for several years he made over his concern (before 1816) to his friend, one Mr. Grey, under whose roof he led his bachelor life till his death on June 1, 1842 at the age of sixty-seven. Instead of returning to his native country, like the rest of his countrymen, with the competence he had acquired, he adopted for his own the country of his sojourn, and cheerfully devoted the remainder of

1 *A Biographical Sketch of David Hare*, by Peary Chand Mittra. Calcutta 1877.

his life to the one object dear to himself, namely, the spread of Western education, for which he spared neither personal trouble, nor money, nor influence.

As early as 1815 Hare formed an estimate of the educational needs of the country, and determined that there should be English schools, vernacular schools, and the supply of good English and vernacular books on an extensive scale. A man of great energy and strong practical sense, he fell in with Ram Mohun Roy's scheme of reform, but urged that the cause of social and intellectual reform in this country will be better served by establishing a school or college for the instruction of Bengali youths.[2] Ram Mohun Roy, whose desire for English education of Indian youths was no less enthusiastic, agreed to the strength of Hare's position and was able to attract gradually the attention of the leading citizens of Calcutta and, among others, that of the Chief Justice Sir Edward Hyde East who took a lively interest in the matter.[3] After ascertaining that the leading members of the Hindu community in Calcutta were favourable to the proposal, Sir Edward mooted the subject in several meetings held at his house and came to the conclusion that "an establishment be founded for the education of native youths". A large joint committee of eight[4] European and twenty Indian gentlemen was appointed to

2 Peary Chand Mittra, *op. cit.*, p. 5; S. D. Collet, *Life and Letters of Raja Rammohun Roy*, London 1900, pp. 21-22.

3 Kissory Chand Mittra tells us that two years after his settlement at Calcutta (early in 1815), Ram Mohun established at his own expense a Free English School at Suripara, with about 200 boys. Ram Mohun Roy's Anglo-Hindu School which developed out of it did not start on the new premises at Simla near Cornwallis Square till 1822 (Collet, *op. cit.*, pp. 49, 71). His letter to Lord Amherst on English education was written in December 11, 1823. But the story of Ram Mohun Roy's share in the inauguration of the Hindu College is told by Sir Edward Hyde East in his letter to J. Harrington (dated May 18, 1816), quoted in *JBORS*, xvi, pt. 2, p. 155 f. The opposition of Hindu orthodoxy to Ram Mohun's active participation in the scheme is referred to in this letter.

4 Kissory Chand Mittra (*The Hindu College and its Founder*, Appendix B to Peary Chand Mittra, *op. cit.*, p. viif, at p. xiv) gives the number as ten. The first meeting at Sir Edward's residence was held on May 14, 1816, and more than fifty Hindu residents of Calcutta, including some Pundits, attended the meeting.

carry the resolution into effect, with Sir Edward as President, J. H. Harrington of the Regulation fame as Vice-President and Lieut. (afterwards Major) Irvine and Buddinath Mookerjea as Secretaries. It was subsequently reported that Ram Mohun Roy would like to be connected with the project, but Hare, who had an accurate understanding of the current of public feeling, is said to have persuaded his friend to keep himself aloof from the movement lest Hindu orthodoxy should take alarm at his active co-operation.

The Hindu College, or the Mahavidyalaya (or simply the Vidyalaya) as it was originally called, was the direct result of this movement. It was formally opened on Monday, the 20th January, 1817 at Gora Chand Bysack's house on the Upper Chitpore Road. It was afterwards removed to Roop Churn Roy's house in Chitpore, and then to *Feringhee* Komul Bose's house at Jorasanko. The College represents the first effort made by the Indians themselves for the education of their children in English language and literature. The object of the institution, as described in the printed rules published in 1822, was "to instruct the sons of the Hindoos in the European and Asiatic languages and sciences." It was originally proposed to teach English, Persian, Sanskrit and Bengali, but the first place of importance was assigned to literary education in English, Sanskrit having been discontinued at an early stage and the Persian classes abolished in 1841.[5] The reports of 1827 and 1828 state that "The studies in the Institution were Natural and Experimental Philosophy, Chemistry, Mathematics, Tytler's Elements of General History, Russell's Modern Europe, with Milton and Shakespeare". The institution was meant to supply liberal education in English, but prominence was given to the study of English language and literature, and from 1826 all lectures were delivered in English.

The institution soon grew in popularity, and in course of time claimed superiority over every other institution affording similar instruction. The system of demanding fees from scholars was not

5 Persian was abolished as a Court language in 1836.

at first successful, and the Committee of Management accordingly resolved that from January 1, 1819 the College should be a free institution. But from 1823 the number of paying scholars steadily grew, and at the end of 1825, 1826, 1827 and 1828 it rose respectively to 110, 223, 300 and 336.[6]

The College was started with a fund of Rs. 1,13,179 raised by public subscription, and for several years after its establishment it was strictly an Indian enterprize and received no aid from Government. From the printed rules of the College it appears that "At a meeting held on the 11th June, 1816, the European members withdrew from an active participation in the management of the College desiring only to be considered as private friends to the scheme and as ready to afford their advice and assistance when consulted". Accordingly in December 1816 Gopee Mohun Tagore was elected Governor, and Gopee Mohun Deb, Joykissen Singh, Radhamadhub Banerjee and Gunganarain Dass were made Directors of the institution, with Buddinath Mookerjea as secretary; these also formed the Committee of Management, which was elected annually. Hare was nominated a Visitor of the College on June 12, 1819, and among the early friends of the institution must be mentioned Ram Komul Sen, and Raja Radhakant Deb, who succeeded his father Gopee Mohun Deb as an active member of the College Committee. But the financial position of the College was not all that could be desired. The monthly income[7] between 1824 and 1833 fluctuated between Rs. 800 to Rs. 3,272; but the greatest financial catastrophe came

6 In 1819 the *total* number of scholars was 70 but it increased to 196 in 1826, and 433, 421, 409 in 1828-29-30 respectively (F. W. Thomas, *History and Prospects of British Education in India*, p. 27).

7 In 1824 the monthly receipts of the college amounted to Rs. 840. At the end of 1826 they came up to Rs. 1,115, and two years later to Rs. 1,700. In 1830 the total income rose to Rs. 3,272, of which Rs. 1,500 were raised by fees alone. But there were vicissitudes, and at the end of 1833 we learn that the receipts had fallen off to Rs. 800. Since then, with Government aid, there was a gradual increase till the sum reached Rs. 30,000. The individual tuition fee charged from all classes, junior and senior, was at first Rs. 5, but it was afterwards raised to Rs. 8 in the college department, Rs. 6 in the senior school and Rs. 5 in the junior school.

with the failure of J. Baretto, in whose firm the subscribed capital was deposited, although after a delay of two years the Management were fortunate enough to retrieve Rs. 21,000 out of the wreck of the firm. Partly from this loss of its endowments, partly from inexperience and partly also from the apathy of its original supporters, the affairs of the College were in a bad way, and we have the contemporary testimony, recorded later on by Alexander Duff, that "had it not been for the untiring perseverance of Mr. Hare, the college would have soon come to an end." In 1823 the Management in their financial difficulty applied to Government for aid and for providing a suitable building. Government came generously forward to help the institution[8] but on the understanding that the Committee of Public Instruction would be given the right of supervision over the administration of funds supplied by Government. These conditions[9] were accepted, and Dr. Horace Hayman Wilson[10] (1786-1860) was nominated on behalf of

8 The Government aid in the first instance was to the extent of Rs. 300 a month. In 1827 it was raised to Rs. 900, and in 1830 to Rs. 1,250 a month. In 1829 Government made an additional grant of Rs. 5,000 for purchasing books for the library. In 1840 the contribution of Government amounted to Rs. 30,000, and it began from this time to take a more active interest in the affairs of the college through the Committee of Public Instruction. In course of time the interference went further, and a collision of authority raised the general question of the management of the college. In a conference held in 1844 of the leading members of the two bodies, the Indian members agreed to withdraw their connexion with the college in consideration of Government undertaking to enlarge and improve the institution. As a consequence the Hindu College as such was abolished, the junior department continuing in the shape of the Hindu School, and the senior department as the Presidency College, of which it formed the nucleus. In this way Presidency College as such came into being as the first Government College for imparting European education to Indian youths.

9 There was at first a protest from Radhamadhub Banerjea and Chunder Coomar Tagore who were suspicious of Government interference and maintained that the institution might be left to its own resources. But on an assurance received from the Committee of Public Instruction that their supervision would be limited only to the funds supplied by Government, their financial assistance was accepted, chiefly through the persuasion of David Hare.

10 Wilson, who is chiefly remembered to-day as a Sanskritist, had a varied career as a linguist, historian, educationist, chemist and numismatist. Born in Sept. 26, 1786 and educated at St. Thomas's Hospital in London, he came to Calcutta in 1808 in the medical service of the E. I. Co., but was attached, for his knowledge of Chemistry and

Government as Visitor to the College. He was accordingly elected an ex-officio member of the College Committee and became its Vice-President. Hare was made an Honorary member of the Committee. Through the influence of these two men arrangements were at last made for the erection of a building to house the College, but it was proposed that the building should also accommodate the Calcutta Sanskrit College. David Hare made a gift of the piece of land he owned on the north side of the College Square, where on February 25, 1824 the foundation stone of the Hindu College was laid. The building was completed and occupied by the College on May 1, 1826.

From the brief sketch of the origin of the Hindu College given above it is clear that the credit which is usually given to David Hare not only for its foundation but also for its continuance is not unjustified; but in saying this no injustice is done to those who toiled and strove with him loyally in the achievement of the same object. The idea originated with him, and his eagerness to translate it into reality proved a stimulating power in the circle of those who knew him and shared his faith and determination. Without the support of his able coadjutors, not much perhaps would have been achieved, but the moral force behind the venture was supplied by his indomitable, if unobtrusive, optimism and perseverance. He allowed himself to be made an honorary member of the Committee of Management only at a later stage; but even in an unofficial capacity he watched over the institution with a parent's

Assay, to the Mint at Calcutta, of which he was appointed Assay-master in 1816. He studied Sanskrit, contributed widely to the learned journals of the day on a variety of subjects, and became Secretary to the Asiatic Society of Bengal in 1811-33, with short intervals. He was also Secretary to the Committee of Public Instruction. He subsequently became the first Boden Professor of Sanskrit at Oxford (1832), Librarian of the India House (1836), F. R. S. (1834) and Director of Royal Asiatic Society from 1837 till his death on May 8, 1860. His well-known publications on Oriental literature are: *Select Specimens of the Theatre of the Hindus*, 2 vols. (1826-27); Translations of the *Meghadūta* (1813), the *Viṣṇu Purāṇa* (1840), and the *Ṛg-Veda* (6 vols); a Sanskrit-English Dictionary (1819; new ed. 1832); new edition and continuation of Mill's *History of British India* (1844-48) and of Macnaghten's *Hindu Law: a Glossary of Judicial and Revenue Terms of India* (1855); *and Lectures on the Religious and Philosophical Systems of the Hindus* (1840)

tenderness throughout the experimental stage, and this feeling did not abate even after it had struggled to stability and distinction.

It would be unjust to criticise the motive which prompted him to inaugurate this decisive movement towards Western education as an insidious attempt to westernise the East. Men like Hare and Macaulay sincerely believed that they were going to ensure to India "the vast moral and material blessings" arising out of the general diffusion of useful knowledge; but it must not also be forgotten that the demand had come from the people themselves before it was thrust upon them. Even though these pioneers of English education in Bengal made no attempt at concealing their deep and vital conviction of the material and moral superiority of the West and in giving effect to the wide-spread belief in the efficacy of "useful knowledge", yet in introducing an alien education they did nothing more than gauge accurately the signs of the time and gather into a focus the growing popular demand. But Hare did more than merely share in this belief of the age. He had also the conviction that the Indians never lacked the elements of greatness and prosperity in their mental equipment and material resources of the land, and that all they needed at a critical time of their history was a potent and rational stimulus in the shape of the quickening influence of Western knowledge in order to reawaken in them the spirit of enterprise and thirst for knowledge which had been for the time being extinguished. His faith in what he considered to be the proper destiny of the Indian people and the remedial virtue of English education found an embodiment in the Hindu College and in the schools which were brought into being. Hare's life was rich in sympathy and service and in the inspiration which comes from a lofty aim steadily pursued, and for these reasons his influence was great: but even his influence could not have ensured the ultimate success of the movement had not the time been opportune for its appearance.

In March 1826[11] Henry Louis Vivian Derozio, a pupil of

11 See Brajendranāth Bandyopādhāy, *Sambād-patre Sekāler Kathā*, vol. i, p. 28. Edwards (*Henry Derozio, the Eurasian Poet, Teacher and Journalist*, Calcutta

David Drummond at the Dhurmtollah Acadamy, was appointed[12] teacher of English literature and History in the Second and Third Classes of the Hindu College. This appointment, seemingly so insignificant, was destined to mark the early development of one of the most important movements in the intellectual history of the Young Bengal of this period. When Derozio came to this college as a teacher he was a lad of barely seventeen, and his connexion with it lasted only for five years; but no other teacher ever taught with greater zeal and with more loving intercourse between teacher and pupil, and no other wielded a more amazing influence on young minds than this Anglo-Indian boy of extraordinary intellectual and moral gifts.

Son of Francis and Sophia Derozio (née Johnson), H. L. V. Derozio was born on April 18, 1809.[13] The house in which he was born stood on the suburban side of the Lower Circular Road, a little to the north of St. Theresa's Church.[14] Although Derozio was the second of a family of five children, his father, who occupied the position of the Chief Accountant in the Agency firm of James Scott and Company, was anxious to give his son the best literary education that could then be obtained in Calcutta. From the early age of six to the age of fourteen Derozio was put in the hands of David Drummond (1785-1843) whose Acadamy has been characterised as the best in the years before the Hindu College. This crooked-back but straight-minded native of Fifeshire, who had drunk deep of the metaphysics and the muse of Scotland and who left his country in 1813 because of his prone-

1884, p. 30) gives the date March 1828, but at p. 66 he speaks of "Hindu College during 1828, a year after Derozio's appointment". E. W. Madge (Memoir of Derozio, prefixed to B. B. Shah's ed. of Derozio's Poems, vol. i, Calcutta 1907) gives the date November 1826. Kissory Chand Mittra gives 1827 as the date of Derozio's appointment. All these dates appear to be incorrect.

12 On Rs. 150 a month.

13 E. W. Madge (*op. cit.*) and F. B. Bradley-Birt (*Poems of Derozio*, p. iv) give the date as the 18th April; while Edwards (*op. cit.*) and other authorities give it as 10th April. The former date appears to be the correct one.

14 The house is now pulled down and replaced by a modern residence. Derozio's mother was an Englishwoman, while his father was a Eurasian of Portuguese descent.

ness to free thinking, watched the precocious and impulsive Derozio with interest, and fed his young intellect and imagination with all that was best in the poetry and philosophy of the West. Derozio became little of the usual classical scholar of the day, for his chief delight was in the literature and thought of England as embodied in its best thinkers and writers, and he imbibed not a little of his master's inclination towards free thinking. On leaving school in 1823 he became a clerk in his father's office, but the drudgery of the desk had no fascination for him. At the age of nearly sixteen he left the office-stool for the varied work and life of an Indigo-planter under the hospitable roof of his uncle Arthur Johnson at Bhagalpore. There, with the ripple of the river in his ear and its music in his heart, the boy-poet began to weave his *Fakeer of Jungheera,*[15] an immature production, no doubt, but his most sustained and remarkable effort in poetical composition. It is not known on what date he returned to Calcutta, but he published in 1827 his first volume of *Poems,*[16] dedicating it to Dr. John Grant, Editor of the *India Gazette,* to which he used to send his youthful poetical contributions under the signature of Jevenis. His poems show the obvious influence of Byron and Moore, but they also indicate considerable poetic feeling, play of fancy and gift of expression. He is said to have been appointed sub-editor of the Gazette, and his literary attainments and fame as a promising young writer, who contributed to some of the literary journals of the day, obtained for him in March 1826 the appointment of a teacher of English literature and History at the Hindu College.[17]

15 *The Fakeer of Jungheera, a Metrical Tale and Other Poems* by Henry Louis Vivian Derozio. Samuel Smith & Co. Hurkaru Library. Calcutta 1828. Dedicated to Horace Hayman Wilson. The work is prefaced by Derozio's well-known sonnets *My country in the day of glory past.*

16 *Poems* by H. J. Derozio. Calcutta, Printed for the Author at the Baptist Mission Press, and sold by Messrs S. Smith and Co. Hurkaru Library, 1827. On the title-page appears a quotation (*If the pulse of the patriot, soldier or lover*, etc.) from Moore's *Harp of Erin.* His best and most representative poems have been collected together recently by F. Bradley-Birt in his *Poems by Henry Derozio* (Oxford University Press, 1923).

17 For more details about Derozio, see Thomas Edwards, *op. cit.*; Peary Chand

Of his teaching, eloquent testimonies have been left by his pupils and contemporaries, but the effect is best seen in the profound, abiding, if at first disturbing, influence which he exerted over the brilliant young minds of that generation. The ground covered by English literature and History in the first three classes of the Hindu College in 1828 will be clear from the curriculum which included, among other things, Goldsmith's History of Greece, Rome and England, Russell's Modern Europe, Robertson's Charles V, Gay's Fables, Pope's Homer's Iliad and Odyssey, Dryden's Virgil, Milton's Paradise Lost and Shakespeare's Tragedies. Derozio taught second and third classes, but his teaching, like that of all great teachers, was not confined to the text-books alone. After college hours and in the intervals of teaching he was ever ready in conversation to aid his pupils in their studies, gave them extra readings from English literature, led them through the pages of Locke, Reid, Hume and Dugald Stewart, and thus laid bare before their vision a new world of ripe thought and daring speculation, a literature and history full of high thoughts and noble efforts. It was about this time that he is said to have written a critique on the philosophy of Kant, a work which is now lost, but which elicited from Dr. W. H. Mills, then Principal of Bishop's College and afterwards Canon of Ely, the high praise of having been "perfectly original" and having displayed "powers of reasoning and observation which would not disgrace even gifted philosophers."[18]

But it was not in the class room that Derozio's buoyant spirit, his ready humour, his wide culture, his ardent imagination, his

Mittra, *op. cit.*; F. Bradley-Birt, *op. cit.* pp. i-lix; *Oriental Magazine*, October 1843 reproduced in the *Bengal Obituary* (1851) and in Owen Aratoon's edition of Derozio's *Poems*; T. P. Manuel, *The Poetry of Our Indian Poets*, 1861; W. T. Webb, *Anglo-Indian Verse* in *India Review*, 1883; H. A. Stark and E. W. Madge, *East Indian Worthies*, Calcutta 1892; E. W. Madge, *Forgotten Anglo-Indian Bards*, a Lecture, Calcutta 1896, and *Henry Derozio, the Eurasian Poet and Reformer*, a Lecture at the Calcutta Y.M.C.A. (Dec. 1904).

18 See *Bengal Obituary* (Calcutta 1851), p. 104. Derozio also delivered a course of lectures on "The Modern British Poets" which was published after his death in the *Calcutta Literary Gazette* of October 13, 1833.

readiness to impart knowledge and free thinking could find adequate expression. In consort with his pupils he established in 1828 or 1829 a debating club, known as the Academic Association, which met at a garden house in Maniktollah belonging to Srikissen Singh. Here night after night, under the presidency of Derozio and with Omachurn Bose as Secretary, the boys of the Hindu College read and discussed and debated all topics of interest, literary and philosophical, and acquired for themselves not only the facility of expression and argument but also the habit of thinking freely as seekers after truth. David Hare, in his white jacket and old-fashioned gaiters, was a regular visitor at these meetings and became President of the Association after Derozio resigned;[19] but the occasional presence of distinguished visitors like Sir Edward Ryan, Dr. Miller and Colonel Benson indicates the high level and interest of its lectures and discussions. Among the members of this Association were Krishna Mohun Banerjea, Russic Krishna Mullick, Kashi Prasad Ghose, Duckina Runjun Mookerjea, Ramgopaul Ghose, Ramtonoo Lahiree, Radhanath Sickdar, Madhub Chunder Mullick, Huru Chunder Ghose, Gobinda Chunder Bysack, Peary Chand Mittra and others,—all of whom became in later times the leading men of their generation. Under Derozio's direction the advanced students of the College issued a paper called the *Pantheon*,[20] but it was soon stopped by Dr. H. H. Wilson, the Visitor of the College. Himself a free thinker, though not a sceptic or an atheist on his own confession, Derozio impressed upon his pupils the duty of thinking freely, but the freedom of thought and action which he inculcated affected their ancestral faith and culminated not only in an open renunciation of Hindu orthodoxy but also in a spirit of aggressive heterodoxy.

The Managing Committee of the College naturally took

19 Peary Chand Mittra, *op. cit.* p. 64. From a letter of Ramgopaul Ghosh, dated Aug. 12, 1838 (quoted in R. G. Sanyal's *Bengal Celebrities*, vol. I, Calcutta 1889, p. 176), we learn that the Academic Association was getting on very miserably after its leading spirit was gone, but it lingered on till March 31, 1839.

20 See *Calcutta Review*, 1911 (On the Vernacular Press in India), pp. 26-27.

alarm and passed a resolution that Mr. D'Anseleme, the Head Master, "be requested, in communication with the teachers, to check as far as possible all disquisitions leading to unsettle the belief of the boys in the great principles of national religion". But the dangerous doctrines of rationalism were producing their first disturbing effect, and the rising tide of free enquiry could not be stemmed. Derozio's influence extended over a larger area than the immediate sphere of personal influence. Heedless of the injunction of authorities, young students of Calcutta continued to flock as usual to the meetings of the Association, as well as gather round Derozio's hospitable table in the old house at Circular Road. The authority of the Hindu religion was questioned, its sanctions impeached, its doctrines ridiculed, its philosophy despised, its ceremonies accounted fooleries, its injunctions openly violated and its priesthood defied as an assembly of fools, hypocrites and fanatics. In February 1830 further orders were issued by the Management, calling upon the teachers, on the pain of dismissal, "to abstain from any communication on the subject of the Hindu religion with the boys, or to suffer any practices inconsistent with the Hindu notions of propriety such as eating and drinking in school and class room". The Christian Missionaries of Calcutta, in the meantime, headed by Dr. Duff, availed themselves of this growing unrest and arranged a series of lectures on Christianity at Dr. Duff's house at College Square, nearly opposite the Hindu College.[21] David Hare, hardly an orthodox Christian, was apprehensive of the intentions of the Missionaries, and the

21 It was arranged that the first lecture on the Internal and External Evidences of Christianity was to be delivered by Dr. Duff; the second on the Testimony of History and Fulfilled Prophecy by John Adam of London Missionary Society, a fellow-student of Duff's at St. Andrews; the third on Christ and the Four Gospels, and the Genius and Temper of His Religion by Rev. James Hill, Pastor of the Union Chapel. Dr. Thomas Dealtry (1796-1861), Chaplain of the Old Mission Church (who afterwards succeeded Daniel Corrie as the Archdeacon of Calcutta and then as Bishop of Madras in 1850) was to close the series with a statement of the Doctrines of Christianity. The delivery of the lectures commenced at Dr. Duff's house in August 1830, Mr. Hill delivering a preliminary lecture on the Moral Qualifications necessary for investigating Truth. (See Smith, *Life of Alexander Duff*, pp. 90 f).

Management again met and resolved that the students at the cost of incurring their displeasure should discontinue the practice of "attending societies at which political[22] and religious discussions were held". There was a temporary calm, and the Missionaries discontinued their lectures; but the leaven supplied by Derozio's teaching continued to act. In the excess of their zeal, however, the impulsive young reformers sometimes went beyond the conclusions of their master, and wanted to make progress by actually "cutting their way", as one of the newspapers of the day quaintly expressed it, "through ham and beef and wading to liberalism through tumblers of beer". Orthodox Hindu society saw nothing in the innovating spirit of the young collegians but an element of danger. No less than twenty-five boys were withdrawn and about one hundred and sixty were absent or were not allowed to attend college by their suspicious guardians. Evil reports were circulated with regard to Derozio's personal character and morals; and the teacher had to pay the penalty of the excess of his pupils. On April 23, 1831, the Management met again to take decisive measures for removing Derozio, who was considered to be "the root of all evil", as well as punish the more advanced of his pupils who had publicly displayed their hostility to orthodoxy.

Although Hare and Wilson showed their disapproval of the step, the chief mover in the matter was, curiously enough, Ram Comul Sen (1783-1844), grandfather of Keshub Chunder Sen, one of the most radical reformers of later times. From the humble position of a compositor in the Hindustani Press of Dr. Hunter to which he was appointed in 1804 on eight rupees a month, he became in 1818 a clerk under Dr. H. H. Wilson at the Bengal Asiatic Society, then its Indian Secretary and member of its Council. He gradually worked himself up to a very eminent place in the educated society of Calcutta, and was before his death in August 2, 1844 associated with every educational and philanthropic activity in the metroplis.[23] He compiled and pub-

22 Viz., on the first Reform Bill.

23 Besides being a member of the Managing Committee of the Hindu College, he

lished a Bengali-English Dictionary (1825), a Bengali Hitopadesa (1820)[24] for the Calcutta School Book Society, and had taken an active interest in the spread of European knowledge. But he was also a firm believer in orthodox traditions and therefore viewed with alarm the consequences of Derozio's teaching, which his hot-headed pupils had carried to conclusions far beyond the intentions of their teacher himself. The requisition calling the meeting of the Committee of Management which was drawn up by Ram Comul Sen, is an interesting document, which not only exhibits the alarm and distrust of the Hindu Society but bears also a hint of the base calumines which were industriously circulated against Derozio and which Derozio himself indignantly repudiated and challenged his accusers to substantiate.[25]

In the meeting which followed, Wilson and Hare declined to vote on a question which concerned Indian feelings alone; but the majority condemned Derozio unheard. They admitted that they had neither the power nor the right to enforce the prohibition of private lectures or meetings, but they resolved that it was necessary in the existing state of public feeling to dismiss Derozio as a person not fit to be entrusted with the education of youths. It was also alleged in an intemperate spirit that Derozio was an atheist, and that he had "materially injured their morals" by encouraging immoral practices and by introducing "some strange system, the tendency of which was destructive to their moral character and to the peace of society." Derozio sent in his letter of resignation on April 25, 1831. To H. H. Wilson he wrote a dignified and spirited reply denying the allegations made against him and pointing out the

was on the first committee of the Calcutta School Book Society in 1818, a member of the Council of Education in 1839 and also of the Medical Education Committee. He was appointed Dewan of the Indian Establishment of the Calcutta Mint in 1831 by Dr. H. H. Wilson who was Assaymaster of the Mint, and became a Treasurer of the Bank of Bengal in 1832. See Peary Chand Mittra, *Biographical Sketch of Ram Komul Sen*, Calcutta 1880.

24 See my *Bengali Literature 1800-1825*, p. 158.

25 See his letters to Dr. Wilson and the Managing Committee of the Hindu College in Edwards, *op. cit.* pp. 77-89; Peary Chand Mittra, *op. cit.* pp. 19-27; Bradley-Birt, *op. cit.* pp. xlii f; *Bengal Obituary*, pp. 104-5,

injustice of not allowing him an opportunity of defending himself. At the close of the same year, on Monday, the 26th December,[26] in the midst of strenuous work and youthful enthusiasm, he died of Cholera, watched in his sick-bed through six weary and painful nights and days, by his pupil-friends of the Hindu College.

That Derozio should be called a sceptic or infidel is not surprising, for these names are often given to persons who dare think for themselves; but to make aspersions against Derozio's personal character and to charge him with having inculcated unnatural or immoral principles was a mean retaliation on the part of a narrow orthodoxy, whose citadel his teachings had shaken to its very foundations. A vindication of Derozio is hardly necessary to-day,[27] and if it is necessary it has been already done by his able pupils as well as by his biographer. The earnestness and purity of his teachings as well as of his life are best seen in the way in which they issued in good results such as ever followed in the wake of a sincere striving after truth. Derozio was destined to terminate his short career when others would be likely to commence theirs; nevertheless, he lived long enough to acquire a reputation which is not likely to perish, as being honourably associated with the intellectual and social advancement of his country.

Much has been written on the vagaries of the first students of Western literature in Bengal, who believed that the lights were before them, while all behind was darkness. But it is often for-

26 And not Saturday, the 23rd December, as Edwards states (p. 167). See *Bengal Obituary*, p. 106; extract from *Samācār Darpaṇ* (Jan. 9, 1832) in *Prabāsī, Āṣāḍh*, 1338 B.S.; E. W. Madge, *op cit.* p. vii. Derozio was buried in the Park Street Cemetery. The *Bengal Obituary, loc. cit.*, remarks that his grave was undistinguished among the crowded tombs of the burial ground, but adds that the compilers of the work "have been at some pains to trace the spot in which his remains were deposited and found that the grave is at the western extremity of the Old (south) Park Street Burial ground, next to the monument of Major Maling, on the south". The grave remained unmarked and unhonoured until a few years ago. A memorial stone has now been placed at the expense of an "admiring fellow-countryman."

27 It is curious that Smith (*Life of Alexander Duff*, p 89), in his zeal to glorify the achievements of Duff, should speak contemptuously of Derozio as "a Eurasian of some genius and much conceit"!

gotten that the new learning bred in its recepients a spirit of enquiry and experiment, a yearning for quick advance and a desire for the enfranchisement of the intellect and the emotion from the thraldom of ages, which in their early stages were bound to lead to revolutionary excess. The impulse to this new life came from Derozio, but it would be unfair to hold him responsible for all that some of his youthful and impulsive pupils did in their impatience of restriction and disregard of tradition. Derozio himself had not attained years of maturity, and his connexion with the College was cut short before his work could be completed. It cannot be said that he did not perceive the danger, but it would be too much to say that he deliberately encouraged any refractory spirit. What he wanted to do was to leaven the minds of his pupils with a new spirit of criticism and enquiry by his own fearless love of truth, and to impress upon their sensitive minds all that was best in the literature and thought of the West. If they became pert, pretentious and self-assertive, it was due more to the one-sidedness of their education which made them look to the present and forget the past.

Indeed, the excess of the reforming zeal of those who came out of the Hindu College testified to a radical defect in their system of education. Behind the creation of the College there was hardly any clear creative idea. The facile victory of the Anglicists and Macaulay's complacent scheme of Westernisation, as well as the impact of new and alien ideas, had in its first stage blinded the ardent advocates of the new learning, who had neither the inclination nor the capacity for a just appraisement of the virtue or necessity of all that was distinctive in the culture and traditions of the East. The belief was strong that the light of the West was all that was needed to set one on the way to progress, but it was forgotten that this policy was severing national education from the roots of national life. There was some sympathy with oriental culture, and it was genuine; but instead of aiming at a reconciliation of the two cultures, the policy frankly and aggressively encouraged Westernisation, of which the Hindu College was set up as the nursery. The Sanskrit College and the

Madrassa were suffered to exist as institutions which had outlived their utility, just to cater for people who had hopeless tastes or to promote a certain philosophical or antiquarian purpose. But it was never realised at that period, nor even fully realised to-day, that the oriental learning and cluture, which was lightly condemned or somehow tolerated, had its roots in national consciousness and could not be so summarily dismissed. Inveterate prejudice, on the one hand, and blind following of a new fashion, on the other, stood in the way of a correlation of the two cultures; and a complete break with the past and living in the present came to be regarded as the only cure for intellectual sterility and moral paralysis. No doubt, such a stimulus as was furnished by Western literature was needed at the moment, and it was right that the stimulus was eagerly sought for, but no attempt was made to adapt the old learning to changing social and political needs, or the new learning to national sentiment and outlook.

The new learning certainly did not send the young collegians back to old traditions in order to temper them with the new, but in practice it resulted in a weak and hectic adoption of the externals of an alien civilisation. The freaks and excesses of the Reforming Young Bengal became a byeword. If Macaulay wanted the Indian youth to become "English in taste, in opinions, in morals and in intellect, while remaining Indian in blood and colour," the new scheme of training succeeded in a great measure in bringing about this curious transformation. The Young Bengal did not, generally speaking, attain that balance of mind which a liberal education should bestow, and in the on-rush of the new ideas they had no time to pause and look back and revise their partial notions. At the same time, the moral and intellectual gain was immense. The uncertain vision of the young collegians often led them into strange errors; but they were among the first to protest with courage and independence against the moral and intellectual barrenness of the time. If the new learning gave them a supercilious contempt for everything that was old and an unbounded belief in everything that was new, it also inspired them with a genuine passion for knowledge, a sense of initiative and forward movement, an impatience

with false notions and prejudices, a breadth of outlook and a serious spirit of enquiry. If a measure of straitlaced rationalism still cramped and pressed their minds, the stimulus of rational thinking and independent seeking after truth was always there, as well as an yearning for deliverance and advance, which convinced them of the need of a fresh inspiration and outlook.

All this must be attributed in no small measure to the influence of Derozio on the young minds of this age. Addressing his pupils he wrote:

> Expanding like the petals of young flowers
> I watch the gentle opening of your minds,
> And the sweet loosening of the spell that binds
> Your intellectual energies and powers
> That stretch (like young buds in soft summer hours)
> Their wings to try their strength. O, how the winds
> Of circumstance, and freshening April showers
> Of early knowledge, and unnumbered kinds
> Of new perceptions shed their influence;
> And how you worship truth's omnipotence!
> What joyance rains upon me, when I see
> Fame in the mirror of futurity,
> Weaving the chaplets you have yet to gain,
> And then I feel I have not lived in vain.[28]

And indeed he has not lived in vain. The readiness and enthusiasm of his literary taste and vigour of thought, the spell of his compelling personality, the spontaneity of his youth which placed him in close sympathy and affection with his young pupils, his open, generous and affable nature, his fearless love of truth and hatred of all that was mean and unmanly, his ardent love of India evidenced in his conversation as well as by his writings, his social intercourse with his pupils and sincere efforts for their welfare—all these traits of his character not only won their hearts and their high respect but also produced a ferment in the intellectual and moral history

28 *Sonnet to the Students of the Hindu College*, published in the *Bengal Annual*, 1831 and reproduced in Edwards *op. cit.*

of Bengal, which in its deep and far-reaching effects has scarcely been paralleled since his time.

The Hindu College in its uncompromising modernity became the controlling force of the new movement; and its record thus possesses a peculiar interest and importance in the early history of Western education in Bengal, its failures and its successes being equally instructive. Distrusted in its early years both by the Missionaries and by the orthodox Hindus as a secular institution which was undermining the foundations of belief, the Hindu College passed through times of trouble; but it succeeded in arousing a remarkable ferment of new ideas in the Calcutta of the thirties, and helped materially in the upsetting of old ideas. But neither the influence of an institution nor that of an individual, however powerful, would have succeeded in bringing about this result, had not the times been fully prepared for it. The success as well as the failure of the Hindu College and its products was due to the logic of events which had already paved the way for the passing of the old order and the rising of the new. The overthrow of the old political organisation and the break up of the old social fabric had brought into existence such a state of intellectual ruin and moral chaos that a subtle change was coming over the temper and outlook of the younger generation, only to be intensified by the impetus of new ideas. Time-worn customs and irrational prejudices were losing ground, and if with their new training the Young Bengal wanted to see the world from a new angle, this attitude was prompted, not by a mad spirit of iconoclasm, but by their impatience with false notions, absurd practices and conventional restraints, from which they strove to free themselves even at the cost of alienation from deep-rooted national sentiments and traditions.

Sanskrit Treatises on Dhatuvada or Alchemy as Translated into Tibetan

By Vidhushekhara Bhattacharya (Santiniketan)

In a letter, which is still with me, dated the 30th August, 1925, from the College of Science, Acārya Prafullachandra Ray kindly wrote to me to the effect that he had come to know that in Tibet in the Tanjur there were translations of Sanskrit Tantric works. Accordingly when he was turning over the pages of *Asiatic Researches*, Vol. XX, 1839, for two hours one morning and was gradually becoming despondent he found almost at the end of the volume (pp. 582, 583) the following lines: (1) "*Dṅul.chu.sgrub.pa'i.bstan.bcos*, a work on preparing Quicksilver," (2) "*Gser.sgyur.gyi.bstan.bcos*, a work on turning base metals into gold, (on alchemy)." He was eager to know the contents of these two books and requested me to see if I could help him in this matter. Unfortunately I could do nothing about it so long, but take the opportunity now of his Seventieth Birthday Celebration to make an attempt at giving him the information as far as I can.

The Sanskrit name of the first work mentioned above is *Rasasiddhiśāstra* (Cordier, III, p. 473). But unfortunately the Tibetan translation is now lost, merely the name being found in the Tibetan catalogue. It was by Vyāḍipāda being translated into Tibetan by Narendrabhadra of India and the Tibetan translator (*Lo.tshā.ba*) Ratnaśrī of Oḍḍiyāna. The Sanskrit title of the second work will be *Dhātūvādaśāstra*. According to Csoma de Coros it is included in the Tanjur, Mdo, Kho (=CXXII). But, in fact, it is not there. In the next volume there is a work named *|Gser.'gyur.gyi.bstan.bcos.bsdus.pa* which, if translated into Sanskrit, would literally read *Dhātūvāda-*

śāstrasaṅgraha. But in its colophon we have simply *Dhātūvāda-śāstra* (*Gser.'gyur.rtsi'i.bstan.bcos*), there being nothing of *-saṅgrha* (*bsdus*). The Sanskrit title of this work as found in the Tibetan catalogue is, however, *Rasāyanaśāstroddhṛti*. Here the word *uddhṛti* lit. 'drawing out' 'extraction' may have figuratively been used in the sense of *saṅgraha* 'collection.' But *Rasāyana* is not supported by the Tib. version which would read for it *bcud.len*. It may be noted that occasionally Sanskrit *raṣa* is translated, though not appropriately, into Tibetan by *gser.sgyur.ba.rtsi*, as in the *Cittaratnaviśodhana*, 51*a* (while the *Cittāvaraṇa-viśodhana*[1] would rightly translate it by *dṅul.chu* 'quicksilver,' this being actually meant here). Yet, there is nothing to account for *-ayana*. It seems that Coros has not given the fuller title reading simply *Dhātūvādaśāstra* (*Gser.sgyur.gyi.bstan.bcos*). This work is not complete as the colophon itself says *yad-upalabdha* (*ji.sñad.pa*) not adding the word *sumpūrṇa* (*rjogs.so*) as is the case with such Tibetan translations of Sanskrit works. According to the Tibetan catalogue it appears to form a part of Vyāḍipāda's work mentioned above. This *Dhātūvādaśāstra* (or *Dhātūvāda-śāstrasaṅgraha*, or *Rasāyanaśāstroddhṛti*) covers only two and a half folios of the Xylograph.

Besides these two treatises on alchemy there are two more in the Tanjur. One of them is in the same volume (Go = CXXIII; Cordier, III, p. 473). It is entitled *Sarveśvararasāyana* [*sarva*] *rogaharaśarīrapuṣṭaka* (*Thams.cad.kyi.dbaṅ.phyug.gi.bcud.len.nad.thams.cad.'joms.śiṅ.lus.kyi.stobs.rgyas.par.byed.pa.žes.bya.ba*). According to its colophon it is, however, named *Ratnara-sāyanasiddhi* (*Rin.po.che.bcud.len.grup.pa*). It is attributed to one Iśvara (*Dbaṅ.phyug*) and so it has an adjective, *Iśvaropadiṣṭa* (*Dbaṅ.phyug.gis.bstan.pa'i*). It is a very small treatise. It was translated into Tibetan by Śivadāsa of Haridvāra (Hardwar) jointly with the Tibetan translator Ratnaśrī (*Rin.chen.dpal*) of Oḍḍiyāna.

The last work is *Dhātūvādopadeśa* (*Gser.'gyur.rtsi'i.gdams.*

1 Both the works in a volume named *Cittaviśuddhiprakaraṇa* under the editorship of Prabhubhai Patel are in the press and will be published by the Visvabharati.

pa). The Tibetan title, if translated into Sanskrit, would literally read *Suvarṇaparivartanarasa* 'a fluid that turns (a metal) into gold'. This is the common name for alchemy in Tibetan texts. This *Dhātūvāda* is included in the *Tantravṛtti* (*Rgyud.'grel*) section of the Tanjur (Cordier, II, p. 240). It is attributed to one Nalin or Nalina (*Pad.ma'i.rtsa.ba=Padma-mūla*).

Of these four treatises, *viz.*, (1) *Rasasiddhiśāstra*, (2) *Dhātūvādaśāstra* or *Dhātūvādaśāstroddhṛti*, (3) *Sarveśvararasāyana*, and (4) *Dhātūvāda*, No. 1 is, as said before, lost. I want to reserve the treatment of No. 2 for another occasion. And of the remaining two, Nos. 3 and 4 I shall try to give an English translation which must be regarded as a tentative one.

The Xylographs before me of the *Sarveśvararasāyana* and the *Dhātūvāda* are of Narthang edition and belong to the Visva-bharati Library. As regards the *Dhātūvāda* I have examined also the copy of the University of Calcutta which is of the same edition. But none of them is quite satisfactory, there appearing a number of illegible, wrong, or defective readings. The case is almost the same also with the Xylograph of *Sarveśvararasāyana*. The other difficulty in understanding the texts is that the transliterations in Tibetan of some of the Sanskrit words or of the names of different plants or metals are defective or wrong. Besides, owing partly to the subject with which the present writer has no acquaintance whatsoever, and partly to the peculiar style and technique not familiar to him, some passages have been left untranslated, in order that one may not be misled. Yet, it is hoped that the tentative translation given here would enable the reader to form an idea of the contents of the texts we are concerned with. The Tibetan versions are given in the Appendix. The passages are divided in accordance with the sense.

TRANSLATION

I

Sarveśvararasāyana

1. In order to purify quicksilver one should first mix it with the dust of brick (*so.phag.gyi.phye.ma.dan.sbyar*), and crush it seven times. And in that state it is to be kept in the sun.

2. After this it should be purified seven times with the sap (*dugdha* or *kṣīra, 'o.ma*) of *Akon* (=*Arka, Calotropis Gigantiya*?). In that state it is to be kept in the sun.

3. In the same way as before let one proceed with the sap of each of the following plants : *Varuṇa* (*śin.ba.run*. but the actual reading is *ba.'un, Croeva Roxbrughii*), *Kaṇṭakārī* (*Solanum Jacquini*) with its thorns, *Kumārī* (*Clitoria Ternatea*? *Ghṛta kumārī, Aloe Indica*, is also called *Kumārī*), as well as with the solution of a medicinal salt called *mdzo.tshwa* (in Tibet), The quicksilver after being treated in this way becomes fit for use.

4. Three leaves of *Laiṅgī* (=*Liṅginī*, called *Śivaliṅga* in Bengal) which is used as medicine, and plentiful flowers and stalks of *Kaṭukā* (*Kaṭkī* in Bengal, *Pierorrhiya Kurroa*) [together with] an adequate quantity of the sap of *Raktaphala* (Indian Fig?) poured into a pot, are to be crushed, dried, and made into straight theads.

5. One desirous of purifying copper is to make it thin and it is to be steeped in acid (*amla, skyur.po'i.nan.du*) for seven days, and likewise in whey (*dar.ba'i.chur khu.la*), and it becomes glossy (*legs.par.bkra.bar.bya'o*). Then the copper with an equal portion of sulphur is to be put in an earthen pot, so that (when it is placed in fire) no smoke can come out. And then it becomes white just like silver.

6. As regards the purificaton of Raṅga[1] 'tin' (*gśa'.tshe*) one

1 *Vaṅga* may be read for *Raṅga*, the Tibetan word meaning both of them.

is to use *Śilārasa* 'gum of *Liquidamber Orientalis*' (*boṅ.ḳhu.ba*[2]) in the same way as before.

7. One desirous of calciniation of (*māraṇa, bsad.*) iron is to make it thin and put it in the urine of a cow with *Triphalā* 'three *Myrobalans*' (*'bru.gsum*[3]), and then it is to be burnt. After this the same procedure is to be followed as with copper.

8. One who wants to calcine (*māraṇa*) mica is to grind it into powder and put it into acid (*amla*), and then the procedure is the same as with copper.

9. ... ...

10. One who wants to root out skin diseases (*rjo.pha.waṅ.-bsad.par.'dod.pas*) is to be fumigated seven times in the sun with leaves of *Girigandhapatra* (= *Gandhapatra* = *Aśvagandhā, Physalia plexuosa* of a mountain), and he should apply the scum of melted butter. Thus, like the copper mentioned before (the affected part of the body) becomes clean and pure.

11. One who wants to purify silver is to use the fluid of the plant *Nirviṣī* (*nir.bi.si'i*) seven times, and it is to be calcined just like iron.

12. Lead[4] is to be calcined like quicksilver.

13. One who wants to purify gold is to use the fluid of the plant *Kāñcana,*[5] and it is to be calcined like copper.

14. The calcination of *Supaḳita* (?)[6] is like that of gold.

2 Does it mean here *Ativiṣā*?

3 Here *'bru* lit. 'the stone of a fruit' (*asthi*') seems to have been used for *'bras.bu* 'phala' and with *gsum* 'tri' it means *triphala or triphalā*. Or is '*bru.gsum* for *bru.bcud.gsum*? If so, it means three kinds of millet-sesame.

4 The Xylograph reads *bhi.ma* probably for *bhī.ma*. This is the transliteration and it appears to be a wrong one for *sī.sa*, Sanskrit *sīsa*. *Bhīma* in Skt. means *Amlavetasa* 'a kind of plant'. But obviously it cannot be meant here.

5 The transliteration in the Xylograph is *ḳa.tsa.na* which seems to be *ḳāñcana*.

6 I do not know what it means. It may be a wrong transliteration (*su.pa.ḳi.ta*) of *Supavitraḳa*. In the *Kalpadruḳośa* of Keśava, GOS, p. 194, in the sense of 'brass' or 'bell metal' there is a word *pavitraḳa*: "*ghorapuṣpam* (Read °*ghuṣyaro*) *pavitraḳam*". It may be that the Tib. translator made a mistake in reading *supaḳita* for *supavitraḳa*. Here *su-* means 'good'.

15. Thus when the purification is made they are all to be taken in equal proportion with three portions of *Harītakī* 'Terminalia Chebula'; and there being made a very fine powder of them all, pills are to be prepared. These pills, each of which is of four *raktikās*,[7] if given to a patient, cure all sorts of diseases.

16. The thing mentioned before is to be soaked in acid and in it the flour of parched barley (*phye*) and bread are (also) to be soaked. Then if one takes only four *raktikās* of it, at a time, for six months, one's hoariness of hair and wrinkles of the body disappear, and one becomes (as beautiful) as the moon........., and a lover's immeasurable love for a woman does not run away. And if a man succeeds (in using the medicine) for six months he does not become languid.

Here ends the *Ratnarasāyanasiddhi*.

II

Dhātūvāda

1

In order to effect the fulfilment to the fullest extent of charity I shall speak of the teaching (*upadeśa*) of Dhātūvāda for those who are explorers.

2

Bilva 'wood-apple', *Dādima* 'Pomegranade', and *sman.-tshos* 'a kind of dye',[1]—these are to be burnt and mixed with sour wine in a copper pot and kept for three days.

7 *Ratis, rati* is a weight = 1/6, 1/7, or 2/15 *māṣakas*.

8 Particulars not known.

1 Its particulars are not known.

3

Thus there will be a paint, and if it is applied first three times, then seven times, and then twenty one times to a thin piece of iron it becomes copper.

4

Quicksilver, clay for making pottery (*ḳham.sa*), and *sems.rtsi* (?)[2]—these are to be mixed with cow-dung. Then if a piece of copper is put into that mixture it turns into silver.

5

Aśvākṣa 'the eye of a horse' (*rta.mig*), *Meṣaśṛṅga* 'the horn of a ram' (*lug.ru*), *Kūrmacarman* 'the skin of a tortoise' (*rus.sbob.-śun-lhags*),[3] and *Silā*[4] 'red arsenic' are to be melted with gold, and into that mixture silver is to be put. Then, if with the eighth part of this solution lead is liquified it becomes silver.

6

Take silver and *ḳāṃsya* 'bell-metal' ('*ḳhar.ba*) in equal portion, and mix them according to the weight of lead. Afterwards when these are liquified in a pot, they all become silver.

7

Eight *palas*[5] of *Mahāmāṃsa* (*śa.chen*),[6] and lead and silver of equal weight, two *palas* of *Sarji* 'natron', as well as of *sman.-*

2 Evidently a particular kind of paint.

3 *Aśvākṣa* and *Meṣaśṛṅga* are two kinds of plants. Whether there is any plant of the name of *Kūrmacarman* I do not know. Nor can I say whether the things implied by these words in their ordinary meanings are here actually meant.

4 In the Xylograph it is tansliterated as *śi.la*. It may refer to *Sallaḳī* 'a kind of plant' (Boswellia Thuripera). See S. C. Das's Dictionary, p. 1268.

5 A particular weight equal to 4 *ḳarṣas* = $\frac{1}{100}$ *tulā*.

6 It means 'human flesh' as well as 'a kind of little shrub'.

tshos,[7] one *pala Viṣaghna* Sebesten, Cordia mysca (latifolia)'[8] (*dug.bsad*),[9] and quicksilver of equal weight—these drugs are to be crushed with the *rasa* 'liqiud' (*ḵhu.ba*) of 'the substantial drug'.[10] And all this to be put in *Śvetaśṛṅga* 'barley' (*rwa.dḵar*) or in an earthen pot.

8

Then having the mouth (of the pot) tied up one is to burn it, till the fire turns into ashes, and when that substance (lit. the medicine) is taken out it will be found changed into silver, (as bright) as the moon.

9

Having taken the foul matter (i.e. pith)[11] inside a stag's horn (*śa.ru* = *mṛgaśṛṅga*) that has just come into being, keep it in the sun and it will melt. Then (this liquid together) with the powedr of lead and silver is to be poured into the clarified butter of a cow (*žum.mar*), and when the water dries up, that matter turns innto silver.

10

Sman.tsha, Vida 'borax' (*tsha.le*), *Yavaḵṣāra* 'an alkali prepared from the ashes of burnt green barley corn', *Sarjiḵā* 'natron', the fluid called *Śvetarasa* (*rtsi.dḵar*),[12] *Viṣa* 'poison' (*dug*),[13] and the urine of a *Hanumat* 'a particular kind of monkey

7 See note 2.

8 See *Vaijayantī* ed. Oppert, Madras, 1893, pp. 49, 1.109; 777.

9 For *bsad* Xylograph reads *pas*.

10 *gdos* (Xylograph *gdus*) *can.sman*.

11 The actual reading in the Xylograph is *bu.ri.śa.na*. It does not give any sense and looks like a transliteration of some Sanskrit or Indian word which seems to be *puriṣa*, here *na* in the text being for the Tib. particle *ni*. It appears that the word *purīṣa*, is used here in the sense of *mala* 'dirt', 'foul or impure matter', not necessarily 'excrement'.

12 Butter-milk and water mixed in equal parts

13 It may mean a particular vegetable poison, *Vatsa-nābhi*. The word *viṣā* means a kind of aconite.

with large jaws and black face' (*ha.nu.man.ta'i.chu*)—mix these with buffalo-curd (*ma.he'i.žo*), and keep lead in this mixture for three days, and burn in such a way that no smoke comes out from it, (and it turns into silver). And thus on acocunt of the change (of a metal) into silver one's poverty and miseries are removed.

11

Now, having described the method of making silver I shall speak of making gold which is just like nectar.

12

In the Himālayas there is a very good and well-known plant called *kuṣṭha* 'the plant Costus specious or arabicus' *ru.rta*), from the leaf of which drips towards the earth (*sa.phyogs*) a fluid having a colour like bright gold. This and the ashes of pure lead (*ža.ñe.dkar.po*), and quicksilver when, according to the instruction given, come into contact with the copper mixed with silver, they turn into gold.

13

First quicksilver is to be put on a fire in such a way that it does not ooze out. Then when one knowing as to how the paint is to be prepared from drugs (*sman.gyi.rtsi*) (applies it) in (proper) way, there is effected gold. If it (quicksilver) does not remain on the fire it does not turn into gold.

14

Therefore (quicksilver) is to be enclosed (in a vessel), having covered its mouth with a circular stopper, and it becomes gold.[14]

Here ends the *Dhātūvādopadeśa* of
Ācārya Nalina.

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14 The last line of the verse is defective and obscure and so it is left untranslated. See the note on the original text.

Appendix

TIBETAN TEXTS

I

Sarveśvararasāyana

[Mdo. Go. 1*a*. 1] rgya.gar.skad.du/sarveśvararasāyana
-rogaharaparipuṣṭaka nāma/

bod.skad.du/thams.cad.kyi [2] dbaṅ phyug.
bcud.len.nad.thams.cad.'joms.
śiṅ.lus.kyi.stobs.rgyas.par.
byed.pa.žes.bya.ba//

thams.cad.mkhyen.pa.la. [3] 'tshal.lo//

1. daṅ.por.dṅul.chu.sbyaṅ.ba i.don.du.so.phag.gi.phya. ma.daṅ.sbyar.la.lan.bdun.gyi.bar.du.btags.śiṅ.sbyaṅ. [4] par.-bya'o/de'i.skabs.su.yaṅ.ñi.ma.la.bdug.por.bya'o//

2. śiṅ.a.kon.gyi.'o.mas.lan.bdun.gyi.bar.du.btags.śiṅ. [2 *a* 1] sbyar.bar.bya'o/de'i.skabs.su.yaṅ.ñi.ma.la.bdug.par.bya'o//

3. yaṅ.śiṅ.ba.'uṅ.gyi.'o.mas.sṅar.bžin.no//ka.ndi'i. [2] žes.bya.ba'i.śiṅ.tshe.ram.can.gyi.khu.bas.sñar.bžin.no//ku.ma.ra (x ri) 'i.khu.bas.sṅar.bžin.no//tsi.tra'i.khu.bas.sṅar.bžin.no// mdzo. [3] tshva.khu.bas.sṅar.bžin.no//sman.de (x da). rnams.-bkrus.śiṅ.dṅul.chu.bzuṅ .ṅo/ /

4. liṅ.gi.žes.bya.ba 'i.sman. 'dab.ma.gsum.pa/ro.tsha.ba [4] me.tog.mo (x ma) d.pa.daṅ/sdoṅ.bu.thog (X mthog) btsam.-yod.pa'i.khu.ba.blugs.nas.btags.pas.skram.śiṅ.skud.pa.ltar.draṅ.-du.'dod.par.'gyur.ro//

5. [2 *b*. 1] zaṅs.sbyoṅ.bar.dod.pas.srab.mor.byas.la.skyur (X skyar).po'i.naṅ.du.žag.bdun.gyi.bar.du.sbaṅ.ṅo/dar.ba'i.chur. khu.la.yaṅ.de.bžin.no/legs.par.bkru.bar. [2] bya o/de.nas.zaṅs.-daṅ.mu.zi.mñam.par.byas.la.dza.go. (for rdza.bo) .naṅ.du.du.-ba.mi.'chor.bar.bya'o/dṅul.lta.bur.dkar.por.'gyur.ro//

6. gśa' (X bśa) tshe.sbyoṅ.ba [3] la.boṅ.khu.bas.sṅar.bžin.-no//

7. lcags.bsar.par. 'dod.pas.ba'i.chu.la.'bru.gsum.btab.la.-srab.mor.byas.la.bžug.go//bcug.pa.ni.bsreg. [4] pas.so//phyi-nas.kyaṅ.'bru.gsum.bcug.la.zaṅs.bžin.no//

8. lhaṅ.chor.bsod.par.'dod.pas.žig.tu.btags.la.skyur (X skyar) .pos.bcug.la.zaṅs.bžin. [5] no//

9. a.ra.dha.'i.lo.ma.ni.gñen.po. (or gñan) yin. te.zaṅs.-bžin.no//.ba'i.lca.thag (?) .kha.mnan.par.bya'o//

10. rjo.pha.waṅ.bsad.par.'dod.pas.gi. (X ki) .ri.gan.dha'i.lo. [3 *a*. 1] mas.ñi.ma.la.lan.bdun.budg.par.bya o./mar.khu.cha.na. bcug.pa.sṅar.gyi.zaṅs.bžin.no.dkar.por.soṅ.ba.ni.'byoṅs.pa'o//

11. [2] dṅul.sbyaṅ.bar.'dod.pas.nir.bi.si'i.khu.bas.lan.-bdun.gyi.bar.du.lcags.bžin.du.bsar.bar.bya'o//

12. ji.ltar.dṅul.chu.bsar.ba.bžin.bh'i.ma.la.yaṅ. [3] bsar.-bar.bya'o//

13. gser.sbyaṅ.bar. 'dod.pas.ka.rtsa.na 'i.khu.bas.ji.ltar.-zaṅs.bsod.pa.bžin.bya'o//

14. ji.ltar.gser.gsod.pa.bžin.su.pa.ki.ta.yaṅ.de 4 bžin.no/

15. de.ltar.sbyaṅ.ba.thams.cad.cha. mñam.por.byes.la.a.-ba.ra.ni.cha.gsum.mo//de.ltar.žib.tu.btags.la.goṅ.bur.bya'o. / nad.pa.la.ra.ti.bži. 5 bži.byin.na.nad.thams.cad.'phrag.go//

16. skyur.po.daṅ.sṅo.sbaṅ .ṅo / phye.daṅ.khur.ba'ṅ.drug.-tu.zas.na.skra.dkar.daṅ.gñer.ma.spoṅ [3 *b*. 1] zla.daṅ.mñam.mo /mtshon.gyis.ma.tshod.ciṅ.bud.med.la.khu.ba. 'pho.bar.mi.-'gyur.ro/zla.ba.drug.gi.bar.du.grub.phyin.na.'byiṅ.ba.bsad.do //

Dbaṅ.phyag.gis.bstan.pa'i.rin.po.che'i.bcud.len.grub.pa.-rjogs.so//

II

Dhātūvāda[1]

[45*a*. 4] rgya.gar. skad.du/dhā.tu.vā.da.nā.ma//
bod.skad.du/ [5] gser.'gyur.gyi.rtsi.žes.bya.ba//
yum.rdo.rje.phag.mo.la.phyag.'tshal.lo/

1

sbyin.pa'i.pha.rol. rdzogs.pa'i.phyir/
gser.'gyur.rtsi.yi.gdams.pa.ni/
ñams.su.len.pa'i.gaṅ.zag.la/
tshogs.ni.bsag.phyir.bśad.par.bya//

2

bil.ba.se'u.sman.tshos.daṅ/
se.'bru.rab.tu. [6] bregs.nas[2]
chaṅ.skyur.daṅ.ni.sbyar.bar.bya/
zaṅs.kyi.snod.du.žag.gsum.bžag//

3

de.nas.bdun.gsum.ñi.śu.gcig/
žal.gyi.gdams.pa'i.sman.tshi.yis/
srab.mo'i.lcags.rnams.zaṅs.su.'gyur//

1 In this text the abbreviations VX and CX are for the Xylographs belonging to the Visvabharati and the Calcutta University respectively.

2 The actual reading of the first two lines of the present stanza, as found in the Xylograph, is as follows:

bal.pa.se'u.sman.tsha.daṅ/
sa'u.ra.bsregs.sa/

Evidently it is defective, and so I propose to read them as in the text.

4

dṅul.chu.daṅ.ni.kham.sa.daṅ/
sems (?) 'rtsi.daṅ.ni.lchi.ba.ni/
[7] le.gar (?) .byas.nas.de.yi.dbus/
zaṅs.mar.bžag.na.dṅul.du.'gyur//

5

rta.mig.daṅ.ni.lug.ru.daṅ/
rus[3].sbal.śun.lpags.śi.lar.bcas/
bžus.pa'i.gser.la.dṅul.btab.nas/
de.rnams.bsdus.pa'i.cha.brgyad.kyis/
bžus.pa'i.ža.ñe.btab.byas.nas/
lts.ba. [45 *b*. 2] ltad.ni.dṅul.'gyur//

6

dṅul.daṅ.'khar.ba.mñam.byas.nas/
ža.ñe'i.tshad.du.bsre.bar.bya/
phyi.la[4].snod.kyi.naṅ.du.ni/
žu.bas.thams.cad.dṅul.du.'gyur//

7

śa.chen.sraṅ.ni.brgyad.daṅ.ni/
ža.ñe.dkar.po.de.daṅ.mñam/
sa.j'i.sraṅ.gñis.sman.tsha.daṅ/
dug.bsad.[5] [2] gcig.daṅ.dṅul.chu.mñam/
gdos[6].can.sman.ni.khu.ba.yis/
sda.ma'i.sman.rnams.mñe.bar.bya/
thams.cad.rva.dkar.naṅ.du.bcug/
yaṅ.na.rdja.sa'i.snoṅ.du.ni//

3 VX ru
4 VX *phye.lta'i.* for *phyi.la.*
5 VX *pas.* 6 VX *gdas.*

8

kha.sbyor.byas.nas.bsreg.bar.bya/
sman.thal.bar.du.bžag.nas.bton/
dṅul.ni.zla.ltar.grub.'gyur//

9

[3] skyes.pa.tsam.gyi[7].śa.ru.yi/
bu.ri.śa.ni.blad.byas.nas/
ñi.ma.žu.nas.btab.bar.bya/
de.ni.bzu[8].'gyur.phye.yis.ni/
ža.ñe.dkar.po'i.žun.mar.la/
btab.nas.chu.skam.[9].dṅul.du.'gyur//

10

sman.tsha[10].daṅ.ni.tsha.le.daṅ/
ya.ba.kśa.ra.sa.dzig/
rtsi.dkar.sman.ni.khu.ba. [4] daṅ/
dug.daṅ.ha.nu.man.ta.yi[11].
chu.ni.ma.ha'i.žo.daṅ.sbyar/
žag.gsum.ža.ñe'i.naṅ.du.bžag/
du.ba.mi.'byuṅ.thabs.kyis.bsreg/
dṅul.'gyur.'phoṅs.pa'i.sdug.bsṅal.sel//

11

dṅul.'gyur.sbyor.ba.bśad.byas.nas/
gser.'gyur.bdud.rtsi.bśad.par.bya.

12

gaṅs. [5] can.ri.bo.rnams.la.ni/
ru.rta.ste[12].žes.sman.mchog.grag.la/

7 VX *gyis.* 8 VX *bži* 9 VX *skams.*
10 CX *tshad.* 11 CX *ma.sa.ti'i* for *man.ta.yi.*
12 Vx *ta.*

lo.ms.sa.phyogs.zil.mi.bral/
gser.gyi.mdog.can.khu.ba.'dzag/
ža.ñe.dkar.po.dṅul.chu.ldan/
thal.sbyoṅ.žal.gyi.gdams.pa.yis/
reg.pas.dṅul.zaṅs.gser.du'gyur//

13

daṅ.po.me.yis.dṅul. [6] chu.yi/
mi.'tshor.pa.yi.sbyor.ba.bya/
de.nas.sman.gyi.rtsi.śes.nas/
rnal.'byor.gser.'gyr.'grub.'gyur.ro/
me.daṅ.lhan.cig.ma.gnas.na/
gser.'gyur.'grub.par.mi.'gyur.ro//

14

de'i.phyir.kha.sbyor.'khor.lo.yis/
bciṅs[13].nas.dṅul.chu.bciṅ.bar.bya/
de.bciṅs.gaṅ [7] .yaṅ.gser.du.'gyur/
[14]thams.cad.rdo.rje'i.sku.ru.'gyur//
gser.'gyur.rtse'i.gdams.pa.slob.dpon.
na.lis.mdzad.pa.rjogs.so//

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13 Vx *ci.*

14 Here in VX and CX we have *ze.pa.pa.la* or *zes. pas* (?) before *thams,* but as the metre shows, it is not required, nor does it give any sense. It seems to have been added here from a marginal note.

rdo.rje means *vajra* 'diamond' (or *śūnyatā*), or 'thunderbolt'. *sku.ru* means 'water-wheel', but it has no connection here. *thams.cad.rdo.rje.skur.'gyur* will, however, be in Sanskrit sarve *vajrakāyā bhavanti.*

I am glad that the seventieth birthday of Sir P. C. Ray is being celebrated and I take this opportunity of adding my congratulations and good wishes to the many he is receiving.

He was a student of Professor Crum Brown of Edinburgh University, as I also was some years later, and I felt that this was a link between us even before I had the pleasure of meeting him. I met, some weeks ago, another student of Professor Crum Brown, Sir James Walker, a fellow student of Sir P. C. Ray and I enjoyed hearing something of the happy comradeship that existed in that laboratory in what is now the building of the medical school of Edinburgh University, a comradeship renewed in later years when Sir P. C. Ray revisited Edinburgh.

Sir P. C. Ray's book on the chemical achievements of ancient India roused my own interest long ago: his simplicity of life, his uprightness of character, his devotion to the true welfare of his students and to the true welfare of India have been, I know, an inspiration to my students in Bombay.

A. R. Normand.

Some Difficulties of Wave-Mechanics

By B. M. Sen (Calcutta).

The modern theory of Wave-mechanics owes its origin to the conception of de Broglie that a particle can be regarded as a collection of waves and its apparent position is where these waves are concentrated—virtually a system of wave-groups possessing a group velocity familiar to us in Hydrodynamics. An experimental verification was given by Thomson who obtained interference photographs of these particle-waves. Schrodinger subsequently gave an equation which owes its origin to de Broglie's idea and forms the basis of the entire super-structure of modern Atom-mechanics. Its theoretical basis is weak and it is usual to regard it as fundamental—occupying so to say the same position as Newton's second law of motion in classical Mechanics. Its chief merit at the initial stages lay in the very natural explanation it offered of the continuous and discrete spectra of Hydrogen.

In the hands of Born and his collaborators, it became a statistical equation, giving only the probability of the particle being at any special position. Difficulties then began to appear when Schrodinger's equation was extended to more than one particle and its interpretation sought. The particle-waves now became waves in "phase-space" and not in the Euclidean space of our experience, which is quite different. A real difficulty is thus introduced which deals a severe blow to the simple intuitional idea of de Broglie. It reopens moreover the question of interpretation of Thomson's experiments which is not yet available. It must not be supposed, however, that de Broglie's idea was free from difficulties. It was shown by Heisenberg that the wave-packets would tend to spread out in course of time and the identity of the particle would be lost.

His argument, I believe, has not yet been met. The entire idea is thus in a state of great uncertainty.

It is possible that the difficulty may be solved when a mathematical grounding has been discovered for Schrodinger's equation. It will be remembered that Schrodinger's equation may be derived from the equation of energy by the substitution of a differential operator for the momentum component in the energy equation. No reason can be assigned for this transition from the position and momenta of particles to an equation holding over the entire space. It would even be helpful if the physical idea underlying the transition and the hypothesis made could be clearly stated. But this is not forthcoming and the Schrodinger equation stands as an empirical equation which has led to wonderful results.

A few years ago, Heisenberg introduced his well-known Uncertainty Principle, which asserts that it is not possible to determine accurately the position as well as the momentum of a particle. The greater the accuracy in measuring one, the greater the uncertainty in measuring the other. This principle which is now generally accepted has a curious effect on the Quantum hypothesis. In a recent paper, Darwin makes observation :

"It is rather a striking example of the duality of the quantum theory that one aspect insists that every system always has angular momentum an exact multiple of the quantum, while the other insists that it can never be possible to measure the angular momentum of any system to the nearest quantum; indeed it is really the second fact that allows us to make the first assertion without fear of contradiction".

Taking both these hypotheses together, one cannot help thinking that they imply almost a reversion to the Scholasticism of the Middle Ages when knowledge was inextricably mixed up with belief.

Such are some of the difficulties which confront a theoretical physicist and any light thrown on them will illumine the path to a better understanding of the constitution of matter.

The Mysteries of Matter

By Priyadaranjan Ray (Calcutta).

Matter, energy and life, which may be represented by the three Gunas—Tamas, Rajas and Satwas of the ancient Hindu philosophy, though, strictly speaking, Satwas denotes life rather in a limited sense, meaning perfect consciousness and pure intelligence, form the three ultimate constituents from which the entire physical universe with its living and non-living matter, all forms of radiant and other energy has been evolved.

It is, therefore, no wonder that human endeavours and intelligence have been directed from the very dawn of civilization towards an interpretation of the essential nature of these three fundamental units. This has finally led to the development of different branches of natural and mental philosophy.

Inspite of various philosophical speculations, we have not yet been able to make any notable progress regarding the nature or essence of life. A true scientific explanation of life seems still beyond the range of all probability. Nothing more has been added to our knowledge in this respect than what the ancient Hindu and Greek philosophers taught some 5,000 years ago.

Regarding the knowledge of matter and energy, however, a phenomenal progress has been made within the last two or three centuries, culminating in the revolutionary scientific discoveries of the recent times. Two main branches of science, physics and chemistry, have their growth and development in the study of the nature of energy and matter.

Matter can be viewed in macrocosmic or microcosmic form, and both strike us with wonder when we study their origin, growth, interaction, transformation and disintegration. Astronomy deals

with matter in macrocosmic form, whereas chemistry and modern physics are explaining the same in microcosmic condition. As a knowledge of the part is essential for that of the whole, we will proceed at once to discuss the structure of matter in its smallest subdivisions.

The earliest hypothesis regarding the discontinuity of matter which, at the first sight, appears to be continuous and capable of infinite subdivision, was conceived by the ancient Hindu and Greek philosophers as early as 3,000 B.C., who assumed that matter consists of minute, discrete particles, incapable of further subdivision and separated by empty space. This speculative hypothesis was placed on a scientific basis by John Dalton in the beginning of the 19th century from a study of the laws of chemical change. The terms atoms and molecules thus came into vogue in scientific literature, denoting respectively the smallest particle of elementary and compound substances. The idea that all varities of matter are made up of a limited number of elementary substances, which cannot be further decomposed into two or more unlike substances, was first developed in a scientific sense by Robert Boyle in the middle of the seventeenth century, if we leave out of consideration the abstract conceptions of the ancient philosophers. Atoms were, therefore, represented as the minutest indivisible particles of elementary substances, which can take part in chemical reactions, giving rise to the formation of molecules.

Question then naturally arose, if the atoms again are really the ultimate particles of matter, being continuous in nature and forming hard impenetrable microcosmic units. Is there any limit to the number of elementary substances, or for the matter of that, to the number of different species of atoms? Is there any genetic relationship between them?

We shall now see how these questions have been answered through a series of scientific discoveries.

The Daltoninan atoms, which form the building-stones of the material universe and the foundation of our chemical science, were regarded as minute indivisible particles having unalterable weight

of their own—atoms of the same elements having the same weight and the atoms of different elements having different weights. The macroscopic physical universe is built up by the combination of these minute invisible particles or atoms.

Though this idea dominated the whole of the physical and chemical science for more than a century, still certain relationship between the properties of different atoms was discovered, which inspired the scientific workers with a faith in the unity of matter, running through the diversity of elementary substances. This relationship, as is well known, was discovered by Mendeleeff and Lothar Meyer in 1868-70 and is represented by what is known as the "natural or periodic system" of elements. This consists in a comprehensive classification of the chemical elements bringing out clearly the law of periodicity—"that the properties of elements are a periodic function of their atomic weights."

This generalisation, strongly suggesting a genetic relationship between different types of elementary atoms and hence a common origin for all, seemed for the first time to render untenable one of the fundamental postulates of the Daltonian hypothesis, i.e., the individuality or unalterability of the atom.

In 1834 Faraday enunciated the laws of electrolysis, which showed an intimate relationship between electricity and matter. This was further elaborated by later investigators, leading finally to the development of the theory of electrolytic dissociation by Arrhenius in 1887. The full significance of Faraday's discovery remained, however, unnoticed, till it was pointed out by Helmholtz in his Faraday lecture in 1881. These were the actual words used by him: "Now the most startling result of Faraday's laws is perhaps this. If we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions, which behave like atoms of electricity." As a matter of fact, Faraday's laws may be expressed in a slightly modified form as follows, which correspond closely to Dalton's laws of constant and multiple proportions:

(1) The quantity and quality (positive or negative) of

electricity, associated with an atom or atomic group to form an ion, is constant.

(2) When an atom forms more than one kind of ion, the quantity of electricity associated with the same atom bears a simple ratio to one another.

This at once suggests an atomistic theory of electricity and an intimate association between the material and electrical atoms.

About the same time Sir William Crookes was engaged in investigating the phenomena of the electric discharge in high vacua. This led to the discovery of cathode rays, a glowing pencil of rays coming out of the cathode, which was regarded by Crookes as the "fourth state of matter." Sir J. J. Thomson in 1897 studied the nature of these rays and proved that they consist of negatively charged particles. He also measured their velocity, mass and charge. The charge was found to be equal to that carried by a hydrogen ion—the least qanutity of electricity that is known to be associated with any atom, and the mass to be equal to 1/1840 of the mass of a hydrogen atom. These results were subsequently confirmed by Wilson, Millikan and others. The discovery of the atom of negative electricity or "electron," unassociated with any material atom, was thus made.

But what is more important, the electrons produced had always the same mass and charge, irrespective of the nature of the cathode materials.

The impact of cathode rays upon matter led to the discovery of X-rays by Rontgen in 1895, which was followed by the recognition of radio-activity in uranium salts by Bacquerel in 1897. Soon after Madam Cuire discovered radium and its powerful radio-active properties. These bodies were found to emit three types of rays, α, β and γ rays, of which the β rays were proved to be identical with cathode particles or electrons. It was further found that electrons could also be produced by the action of X-rays upon various substances. But the mass and the charge of the electrons produced by any of these methods from any substance whatsoever remained always unaltered. This led to the unavoidable conclusion that the electron forms a common constituent of all varieties

of atoms. One of the fundamental postulates of Dalton's theory that atoms are ultimate indivisible particles of elementary substances was thus proved to be untenable.

But the atoms as a whole are electrically neutral. So, if units of negative electricity or electrons are a common constituent of them all, they must also possess an equal amount of positive electricity as a counter part in some form or other. Emission of α particles by radio-active bodies, which were identified as helium atoms charged with two units of positive electricity, supplied at once a direct evidence in support of this view.

With the help of these highly penetrating α and β rays emitted by radio-active bodies, Rutherford and his co-workers succeeded in exploring the internal structure of atoms. From a study of the scattering of α particles by thin sheets of metals Rutherford developed the conception of the nuclear atom in 1911, which forms the foundation of our modern atomic theory. According to this the atom consists of a minute positively charged central nucleus, surrounded by a number of electrons—called "planetary" electrons. The nucleus is responsible for practically the entire mass of the atom, and its positive charge is equal to the total negative charge of the surrounding electrons. These planetary electrons determine more or less the physical and chemical properties of atoms. But the accumulation of a number of positive charges within an extremely limited space, as that occupied by a nucleus, would render the latter highly unstable and make it liable to explosively fly into pieces on account of the mutual repulsion of similar charges. It is, therefore, assumed that these positive charges inside the nucleus are firmly held together by a number of binding or cementing electrons. Hence the charge on the nucleus is regarded as a net positive charge. This net charge on the nucleus and hence the number of planetary electrons were also approximately determined by Rutherford and his co-workers, an accurate determination of which was based on the brilliant researches of that young physicist Moseley (1913), who was killed at the age of 23 at the last European war. This led to the introduction of "atomic number" as a more fundamental characteristic of

elements than their atomic weight, and gave a physical interpretation to the entire periodic table. The atomic number of an element thus represents the net nuclear charge of the atom and corresponds to the ordinal number of the element as it occurs in the periodic table. As the hydrogen atom contains the lightest nucleus known and can never acquire more than one positive charge, it is generally accepted that a hydrogen ion or hydrogen nucleus represents the positive unit of electricity. To this the name "proton" is given. The electrons around the nucleus are not at rest, but are in perpetual motion with great velocity in circular or elliptical orbits about it, as has been shown by Niel Bohr and Sommerfeld. Bohr has further proved that these planetary electrons are arranged in different levels, and are distinguished by different energy content. The nucleus consists of protons and electrons packed together in a minute compass. This more or less completes the modern picture of the atom, which thus becomes an epitome of the solar system. The structure of the macrocosmos is repeated in that of the microcosmos or vice versa.

Now if the atomic number or the net positive change on the nucleus determines the physical and chemical nature of the atom, it follows that the transmutation of elements like the conversion of mercury into gold need no longer be a dream of the alchemists, but lies within the range of practical probability and could be realized under suitable experimental conditions. Thus mercury with an atomic number of 80 would be transformed into the element no. 79, i.e. gold, if its atomic number or nuclear charge could be reduced by one unit only. Reversibly gold would be converted into mercury, if by any means its atomic number could be made to increase by one unit. The transformation of mercury into gold, therefore, involves simply an expulsion of a proton from, or an injection of an electron into, the mercury nucleus. As a matter of fact, attempts have been made for the artificial conversion of mercury into gold, and several investigators like Miethe and others claim that, by means of powerful electric discharge, they have been able to obtain gold from mercury. Though these claims have now been disputed, the possibility of

such artificial transmutation can no longer be denied. That transformations of one element into another are continuously going on in nature, is proved by the spontaneous disintegration of radioactive substances. Further, Rutherford and his co-workers have succeeded in bringing about the artificial disintegration of non-radioactive lighter elements like boron, nitrogen, phosphorus, aluminium etc. by the impact of long range α particles from Radium C. The atoms of all these elements, on being disintegrated, set free protons, proving further that the latter forms one of the constituents of all atomic nuclei.

As each element is characterised by its atomic number and not by its atomic weight, it becomes clear from what has been said above that atoms of one and the same element may not possess the same mass. In other words, all elements are not necessarily homogeneous. By suitable adjustment of protons and electrons in the nucleus, the atomic number of an element might be kept unaltered, though the atomic mass would vary. Elements with the same atomic number but with different atomic mass are known as "isotopes." The isotopic elements possess the same chemical properties, hence they are inseparable by any chemical means. Such isotopes were first discovered by Soddy among the radioactive bodies, this was followed by their discovery among the ordinary non-radioactive elements by Thomson and specially, by Aston in 1919 with the help of positive ray analysis. Most of the ordinary elements have been found to be a mixture of isotopes and non-homogeneous in character. This violates the second important postulate of Daltonian hypothesis, that the atoms of one and the same element have got the same mass.

We thus find that the atoms are not hard and impenetrable particles, but like the matter itself in bulk are highly porous and discontinuous. They are built up of positive and negative units of electrical energy, "protons" and "electrons." It is further proved that electricity also, like matter, consists of atoms. A unity running through the diversity of chemical elements, previously hinted at by the Periodic Law, is thus definitely established.

The very fact, that material atoms are made up of units of

electrical energy, at once gave an impetus to the search after the real relationship between matter and energy in general. This has resulted in a striking generalization of great fundamental importance, which we shall discuss readily.

Every one of us is familiar with the law of conservation of energy, which, like the law of conservation of mass, states that energy is never destroyed, but can only change its form. Heat, light, electricity and motion are the different modes in which energy appears to us. Of these, the radiant energy or the energy of radiation, which has given expression to this universe, is the first to be thoroughly investigated. As early as the seventeenth century Newton suggested that light consists of particles shot out in all directions from the luminous body, and developed the "corpuscular theory" of light. In the 18th century this view was discarded in favour of the "undulatory theory" of light, which asserts that light is transmitted by means of waves in that all-pervading medium, known as the "luminiferous ether." Faraday and Maxwell further proved that all radiations are electrical in their nature, and that light waves are only very short electromagnetic waves. Thus energy, both electrical and radiant, were supposed to consist merely of waves and to be continuous in nature. In 1900 Planck, however, showed that material atoms are incapable of absorbing or emitting radiation continuously, but can do it only in integral multiples of a fundamental unit or "quantum." This has given rise to what is known as the quantum theory of radiation. These "light quanta" are called "photons." Hence radiant energy may again be regarded as made up of discrete units like electricity and matter. But both the wave theory and the quantum theory of radiation have their own defects, and one cannot explain fully all the phenomena of radiation without the help of the other. Hence radiant energy has come to be regarded to behave as if in a dual capacity, sometimes as waves and sometimes as showers of corpuscles or photons.

We have already discussed that matter is discontinuous, and is made up of protons and electrons. Bohr has further proved that an atom emits or absorbs radiation in a discontinuous way,

when the planetary electrons move from one level to another. Thus a close genetic relationship is established between matter, electrical energy and radiation. The analogy between radiation and matter has been pushed further ahead within the last few years by de Broglie, Schrodinger and others. These investigators have shown that atoms need no longer be considered as an assemblage of particles like protons and electrons, but may be regarded with advantage as a source of waves. This has laid the foundation of a new branch of physics, known as "Wave Mechanics." As a matter of fact, it has been demonstrated by Thomson and others that a shower of electrons behaves exactly like a system of waves, producing diffraction patterns under suitable conditions. Similar phenomenon has recently been observed also with moving protons by Prof. Dempster. Hence electricity and matter also can behave in a dual capacity like radiation. This seems to link up closely all the different forms of energy with matter.

There are, however, more direct evidences regarding the relation between matter, electricity and radiation, or between matter and energy in general. Sir J. J. Thomson showed that the mass of a charged body increases with its motion. This seems to violate the law of conservation of mass for the first time in science. And as all atoms are made up of charged particles, protons and electrons, the mass of an atom should, therefore, vary with the speed of its motion. Einstein in 1905 further proved that this holds good not only with the energy of motion, but with all forms of energy. In other words, energy of a body always contributes towards its mass. Hence the mass of a body may be regarded as consisting of two parts, rest mass and energy mass, the former is fixed and corresponds to the mass of the body at rest, while the latter is variable and dependent on its energy content. This energy mass is, however, exceedingly small and forms only an infinitesimal part of the entire mass of a body. Radiation, being a definite form of energy, should, therefore, possess mass. In fact Maxwell in 1873 showed that light exerts a pressure against any surface on which it falls. This has been subsequently proved in 1900 by Nichols and others. If radiation possesses mass, then

it should naturally exert a pressure. Hence, when an atom emits radiation it loses a fraction of its mass, and when it absorbs radiation it gains in mass. The total mass of radiation, emitted by our sun, has been calculated by the astro-physicists to amount approximately to 250 million tons per minute. Our sun is, therefore, losing its weight at this rate. The same holds good with all other luminaries in the heaven. But compared with their total mass this constitutes only a negligible quantity. This is, however, not the only way in which matter is being annihilated or transformed into radiant energy. It has been assumed by the scientists that high up in the depths of space, in and around the suns and stars, syntheses of different elementary atoms from protons and electrons are continually taking place. Due to the "packing effect" of protons and electrons in the narrow compass of the atomic nuclei, there occurs a loss of mass, which appears in the form of "photons" of radiation. This accounts for the discrepancy observed between the atomic mass of many elements and the sum of the individual mass of protons and electrons, constituting the atom. Another probable way for the annihilation of matter and the generation of "photons" in the form of that highly penetrating radiation, generally known as "cosmic rays," has been advanced by Sir James Jeans. Far out in the depths of space protons and α particles—the latter representing the doubly charged helium nucleus—are continuously rushing towards electrons around them with an enormous speed under their mutual attraction, till they coalesce and their charges are neutralised. The energy of combination is then liberated in the form of photons of cosmic radiations. These photons of neutral particles having the mass of hydrogen and helium atoms are known as "neutrons." Recently Chadwick and his co-workers have been able to obtain positive evidence of the existence of neutrons in many atomic nuclei.

We thus arrive at the conclusion that the terms matter and energy are really interchangeable. Matter is made up of units of electrical energy and, when annihilated, gives rise to photons of radiation. Radiation again is generally electrical or electro-

magnetic in character. Both as showers of particles and systems of waves matter closely simulates radiation. The two separate laws of conservation of mass and of energy should now be replaced by the single law of conservation of mass plus energy. Sir James Jeans has very significantly summed up the whole matter in the statement—"Matter is bottled-up waves, whereas radiation consists of unbottled waves. The process of annihilation of matter is merely that of unbottling the imprisoned wave-energy and setting it free to travel through space. The whole universe is thus reduced to a world of radiation, potential or existent." In other words, matter is energy condensed, energy is matter disintegrated. There is only one fundamenal entity—a dualistic electrical entity (as protons and electrons)—which appears either in the form of matter or energy in a dual capacity of continuous and discontinuous character. Regarding the nature of this latter, we should better not discuss, as that would lead us into much deeper waters, which science has not fully penetrated, and of which one can only speculate. It is possibly unknowable, or a knowledge of it might ultimately prove that all that we now call realities are but mere shadows or "maya"—a conclusion, which the Vedanta system of Hindu philosophy reached some 5,000 years ago. Things are not what they seem! Anyway we arrive here at a very dangerous ground, and at which, as the saying goes, one must not rush in.

The Inter-Provincial Trade of Bengal and its Problems

By **Narendra Nath Law** (Calcutta).

In availing myself of the opportunity of contributing as my tribute of respect an article to the 'Acharya Prafulla Chandra Commemoration Volume', it is natural that I should try to select a subject calculated to be of interest to the great savant, patriot, and industrialist, whose energies have long been directed, beyond the limits of his laboratory, towards the industrial renaissance of Bengal and her economic uplift from the present decadent condition. To chalk out the path of future economic progress for Bengal and to have a settled line of action, it is necessary to realize accurately the nature of the problems before us by obtaining a view of some of the aspects of the present economic position of the Province. Otherwise, our endeavours are likely to lead to waste of money, materials and energy in spite of our keen enthusiasm and laudable ideals. A complete investigation of this nature is, however, too elaborate to be dealt with within a single article. As the task permits of a division, it is proposed here to make a survey of the trade of Bengal with the other provinces of India with a view to ascertain its character and the problems arising from the same.

The Scope of the Article

Factors complicating the Study of the Subject

The scope of the investigation is thus narrowed down to a survey of the imports of commodities from other provinces into Bengal and her exports to the former. Such a survey would enable us to determine the position of Bengal in the inter-provincial trade through a knowledge of her annual income and

expenditure on the basis of the opposite trade transactions. The task is rendered difficult by the fact that no up-to-date statistics are available in regard to the internal trade movements of India. The only relevant statistics compiled specifically for this purpose, though in a very inadequate and defective manner, are to be found in the Internal Trade Statistics (River and Rail-Borne) issued by the Department of Statistics of the Government of India; but even this publication has been discontinued from the year 1922. So the necessary data are to be collected from a number of statistical publications issued with different objects in view, and from estimates available for some years in the past. A further complication with which the present investigation is saddled arises from the fact that the imports of commodities into Bengal from other provinces cannot readily be regarded as being paid for by this Province, because quite a number of such commodities thus imported is destined either fully or partially to be exported outside India. This is due to Calcutta being the port of import as well as the port for the distribution of commodities for three different provinces, viz. Bengal, Behar & Orissa, and Assam. These and other complications noted later handicap the present investigation, the object of which is to survey the movement of commodities into Bengal strictly for home consumption as also the movement of her own produce outside her limits into the other provinces.

Approximately correct Conclusions can be reached in spite of the Difficulty

In spite of the difficulty of the task, it is not altogether impossible to accomplish it in such a manner as to carry it through to reach some dependable conclusions. The method by which this can be done may be briefly explained. In regard to the movements of those commodities for which up-to-date figures are not available, the Internal Trade Statistics (River and Rail-Borne) for the latest year (the year 1920-21 has been taken in the present article) may be relied on with the exercise of some precautions to ensure that the articles selected are sufficiently important and

representative in their character and are such as have not undergone any remarkable changes in the conditions of trade connected therewith. The figures thus obtained may be checked by frequent references to other available trade statistics for the corresponding years to ascertain the net consumption of the particular commodities within the importing province. To this may be added the consumption figures of a more recent date, specifically obtainable from the Reports of special investigations arranged by the Government in respect of particular articles. The total may be regarded as the index of consumption by the importing province of commodities drawn from other provinces and her exports may be estimated in the same way. The conclusions thus reached enable us to appraise approximately the resultant economy involved in the trade dealings of the province. It can serve our purpose if the conclusions can indicate the position in terms of crores and lakhs, leaving scope for uncertainties to operate within the limited range of hundreds and thousands.

The Method followed for ascertaining the Figures

With this general explanation of the nature and significance of the results of the investigation, the method of treatment of the subject of the present article may thus be indicated. Except for articles regarding which recent figures are obtainable from the latest available reports either of departmental administrations or of special investigations initiated by the Government through such agencies as the Tariff Board, Committees, or individual officers deputed for the purpose, the River and Rail-Borne Statistics for the year 1920-21 have been utilised to obtain the basic data regarding both imports and exports of Bengal from and to other provinces. The most important articles generally known to be heavily consumed in Bengal have been taken up, particularly those in respect of which trade conditions have not varied in any appreciable degree during the past decade. The net imports (or the home consumption of commodities imported from other provinces) have been estimated in the following way: The River and Rail-Borne Statistics set forth quantities of the articles

of trade moving between the different 'blocks'[1] spread all over India, among which the Port of Calcutta stands as a distinct block separated from the rest of Bengal. In calculating the net imports from other provinces of any particular article, it has been decided to prepare at the outset separate estimates of the quantities of articles imported into Calcutta from the rest of Bengal as well as of the quantities imported into Bengal (including Calcutta) from other provinces, the figures obtained being set forth in parallel columns. From the total import figures have been deducted (a) the amounts exported to other provices,[2] and (b) such percentages of exports across the seas as are warranted by the knowledge of local trade conditions and the relative proportions of the supplies drawn from Bengal and other provinces to the Port of Calcutta. The result obtained after making these deductions should be taken as the index of the net consumption of articles imported from other provinces into Bengal. The avoidance of a serious compilcation that might have vitiated the calculations has fortunately been made possible by the absence of any foreign imports as well as by the insignificant volume of coastal trade of Bengal in respect of the particular articles selected. This condition has justified the deduction of amounts exported to other provinces from the recorded amounts of imports from the latter for the purpose of ascertaining the net imports of Bengal. The results obtained by the adoption of this method are shown in Table I.

1 For the purpose of registration of the rail and river-borne trade of India, the country was divided into 18 blocks, viz. 9 blocks representing the British provinces, 4 representing the principal port towns (Calcutta, Bombay, Madras and Karachi) and 5 representing the Indian States.

2 The amounts of exports to other provinces are obtained by adding the river and rail-borne exports from Bengal (excluding Calcutta) to similar exports from Calcutta to all other blocks *except Bengal*. [Vide *River and Rail-Borne Trade Statistics of India*, (1920-21), Table III.]

The River and Rail-Borne Trade Statistics give quantities of the internal trade in hundredweights. It is, however, possible to estimate the value of same from the figures available from the Sea-Borne Trade Statistics of the corresponding years which set forth both quantities and values of foreign exports and imports in tons and £. s. respectively by converting the former into cwts. and the latter into rupees at the rate of Rs. 10/- per £.[4] The following estimates of value have been obtained for the articles, for which the net consumption of quantities has been detailed in Table I.

TABLE II

Value of Net Imports of some principal commodities set forth in column (6) *of Table I* (1920-21)[5] *from other provinces into Bengal.*

Commodity	Value Rs.
Coal & Coke	78,26,000
Gram & Pulse	3,55,96,000
Wheat	4,18,77,000
SEEDS	
Castor	38,92,000
Groundnuts	32,32,700
Linseed	27,71,000
Rape & Mustard	4,80,42,000
Sesamum	2,94,000
	Rs. 14,35,30,700

To this total of Rs. 14·35 crores should be added the values of such principal articles of consumption in Bengal as piece-goods,

4 This is the ratio assumed for the calculation of the values of exports in the *Annual Report of the Sea-Borne Trade of British India* for the year 1920-21.

5 Calculations of price are based on the figures for values set forth in the *Annual Report of the Sea-Borne Trade of British India*, Vol. I for the year 1920-21 against corresponding quantities of exports of particular commodities.

salt, galvanised sheets and raw cotton. The method of calculating the value of each of these articles together with the results of the calculations is given below :—

PIECE-GOODS

The necessary data for preparing an estimate of Bengal's consumption of piece-goods of Indian make, manufactured outside Bengal, may be obtained from Mr. G. S. Hardy's "Report on the Import Tariff on Cotton Piece-goods and on External Competition in the Cotton Piece-goods Trade" published in 1929. Mr. Hardy has given concrete figures for the total imports of such indigenous piece-goods into Calcutta for 1927-28 which may conveniently be arranged as under :

Grey Dhutis	487	millions	of yards
Grey (other than Dhutis)	620	,,	,,
Coloured Goods	145	,,	,,
	1,252[6]	,,	,,

(This is exclusive of Bengal's local manufacture)

Regarding Bengal's consumption of the total piece-goods imported into Calcutta, the Report gives a clue to the making of a dependable estimate by laying down the proportions of populations of the different provinces using piece-goods drawn through the Port of Calcutta, in the following manner :[7]

Assam	8	millions
Bengal	48	,,
Behar and Orissa	38	,,
U.P. (5/6 of the total population)	40	,,
Punjab (1/6 of the total population)	5	,,
Total	139	,,

6 Vide Hardy's *Report*, Tables VI, VIII & IX (pp. 31-34).

7 Hardy's *Report*, p. 30.

Following this composition of the consumers of piece-goods having their supplies either wholly or partially through the Port of Calcutta, it will be found that Bengal accounts for 35% of the total imports of Indian piece-goods landed at Calcutta. This percentage applied to the previous figure of 1,252 mill. yards yields 438,200,000 yds. as the share of Bengal's consumption. Taking an average price of 2 as. per yd. Bengal is found, according to the present estimate of her consumption, to be purchasing piece-goods of Indian manufacture from other provinces to the extent of Rs. 5,47,75,000 every year or about Rs. 5½ crores.

SALT

While Bengal has been annually paying this large amount for one of the primary necessaries of life, the amount that is being annually paid by her on account of the consumption of salt is no less remarkable. The amount paid on this score to the indigenous sources of supply located outside Bengal, meeting at present more than two-thirds of her requirements, is inferable from the following table relating to the value of the imports of salt in Calcutta during the year 1931-32:[8]

Imports from Aden	Rs.	43·83	lakhs[9]
Imports from Bombay, Madras, Sind, Kathiawar ……	,,	51·58	,,
Total	Rs.	95·41	lakhs

It can be inferred from a comparative estimate of the degree of dependence of the three consuming povinces (Bengal, Behar and Orissa and Assam), the size of the population in each, and the larger use of salt in Bengal for domestic and industrial purposes, that of this amount, a proportion of well over two-thirds is charged

8 *Report on the Maritime Trade of Bengal* for 1931-32, p. 7.

9 Aden has been treated here as an Indian source of supply, as the salt manufactories there are mostly owned by the investors of Western India.

to Bengal, the rest being paid by consumers in the adjacent provinces which draw a part of their requirements through Calcutta. Bengal by this estimate pays a salt bill of more than Rs. 64 lakhs every year.

GALVANISED IRON-SHEETS

Another important item on which Bengal has to pay a heavy amount is provided by her annual purchases of galvanised and corrugated iron sheets. A good part of this quantity is obtained from the Tata Iron and Steel Works, Ltd. in Behar. The average amount imported annually from the latter into the Port of Calcutta has been estimated at 25,000 tons.[10] Of this amount, Bengal may well be taken to consume about 75%, or about 18,750 tons, which are purchased, even at the present low price of Rs. 218 per ton, at a cost of Rs. 40,87,500 or about Rs. 41 lakhs.

RAW COTTON

Yet another heavy amount is paid by Bengal for the purchase of raw cotton from the Western and Southern India to meet the requirements of her mills and handlooms. The relevant figures in this regard are available from the special monthly statistics maintained by the Commercial Intelligence Department for recording the movement of the trade in raw cotton carried over river and rail.[11] It will be noted from the February (1932) issue of the publication that during the six months, from Sept. 1931 to Feb. 1932, Bengal imported raw cotton from all blocks to the extent of about 285,000 mds., a quantity almost equal to that imported during the corresponding period in the previous year. Deducting from this figure the amount of about 73,500 mds. shown as the imports from the internal blocks of Bengal, we get the figure of 211,500 mds. as representing Bengal's half-yearly imports of raw cotton from the other provinces. The yearly consumption on this

10 Vide *Assembly Debates*, Vol. II, No. 4 of 1932, dated the 24th February p. 1162 (Mr R. K. Sanmukham Chetty's speech).

11 *Raw Cotton Trade Statistics* issued by the Department of Commercial Intelligence and Statistics, Feb. 1932.

basis stands at about 423,000 mds., the value of which on an average price of Rs. 21 per md.[12] is estimated at Rs. 46,53,000, i.e. more than Rs. 46½ lakhs.

The totals of the values thus obtained for the imports of commodities like piece-goods, salt, galvanised iron and raw cotton may now be grouped together as under:

TABLE III

Values of specified commodities imported into Bengal from other Provinces

Commodity	*Value*
	Rs.
Cotton Piece-goods	5,47,75,000
Salt	64,00,000
Galvanised Iron Sheets	40,87,500
Raw Cotton	46,53,000
Total	6,99,15,500

(or approximately Rs. 7 crores)

What is significant about the above articles is that the consumption of these in Bengal bids for an increase from year to year on account of the protective tariff policy of the Government and the present location of the indigenous sources of supply mostly outside the province of Bengal. This policy points to the possibility of a new development regarding the increasing import of sugar and gur into Bengal from provinces like Behar & Orissa and U.P.

The total Imports into Bengal from other Provinces

Ignoring such future developments, the value of the total imports of Bengal from other provinces will be found to be

12 This is the price calculated on the basis of an average of Rs. 200/- per candy of 784 lbs. estimated from the "Graphs showing the trend of wholesale prices 1931-32" published in the *Indian Trade Journal*, dated the 7th July, 1932.

large, amounting to more than Rs. 21 crores (14·35 crores *plus* 6·99 crores, being the totals of Table II and Table III). The estimate should be regarded as extremely conservative, as it does not take into account the consumption of articles of minor importance.

Exports of Bengal to other Provinces

Against such imports, the total value of articles exported from Bengal to other provinces (omitting, of course, the articles of foreign imports) makes a very poor showing. In preparing this estimate, only such articles as Rice, Tea, Jute, etc. of which Bengal is known to have an exportable surplus need be taken into consideration. The following table has been prepared for this purpose and it gives a fair idea of how Bengal's exports stand as against her imports in the balance of the inter-provincial trade:

TABLE IV

Exports from Bengal to other Provinces (1920-21)

Commodity	*Quantity of Net Exports*		*Value of Exports*
Rice (not in husk)	cwt. 6,172,821	Rs. 9,25,92,315	
Less value of Net Imports of Rice (in husk)	,, –1,692,581	Rs. 2,36,96,134	Rs. 6,88,96,181
Jute manufactures ...	,, 2,039,063		,, 5,07,50,012
Tea	,, 189,188		,, 1,05,94,528
Paper (excluding Paste-board)	,, 235,973		,, 27,19,460
			Rs. 13,29,60,181

The values set forth in the above table have been as a rule computed on the same lines as for those shown in Table II. The net vaule of the export of rice from Bengal to other provinces has been ascertained by deducting from the total worth of husked rice exported from this Province the value of imports of rice in husk,

as no over-seas export was made of the latter from Calcutta in 1920-21. Presumably, the imported rice must have been paid for by Bengal in such circumstances. No credit has been taken for imports of jute and tea into Calcutta from other Provinces on the presumption that these were meant exclusively for export abroad. The value of jute manufactures has been calculated by reducing the total weight to lbs. and estimating the number of bags from the latter on the standard weight of 2¼ lbs. for a bag priced 8 as. each. The price of tea has in the same way been liberally estimated on the basis of 8 as. per lb. Of the total exports of paper to other provinces, only 25 per cent has been taken as the share of Bengal on the basis of the estimate submitted by the Titaghur Paper Mills Co., Ltd. to the Tariff Board, stating that of the total imports of paper excluding paste-board, twenty-five per cent represents paper made or likely to be made in India.[13] Articles like manufactured iron and steel and copper as well as machinery and mill work, of which there is a balance of export in favour of Bengal in the internal trade, have not been taken into account as most of the factories manufacturing these articles in Bengal are owned by non-Indian firms, and therefore economically speaking, the profits arising therefrom do not accrue to those, whose interests are truly identical with those of the Province.

The spectacle provided by the last table will appear gloomy if it be further recognised that a good part of the profits earned from the trade in such articles specified in it as Jute manufactures and Paper goes into the pockets of non-Indian firms and investors in this Province.

The Problem

Such being the position of Bengal in the inter-provincial trade, the question very naturally suggests itself—"Can the financial resources of Bengal afford to be so dangerously exhausted from year to year with a regular feature of her 'debits' standing far in

13 Vide *Report of Indian Tariff Board on the Grant of Protection to the Paper and Pulp Industries (1931)*, p. 29.

excess of her 'credits' in the inter-provincial commercial balance-sheets?" The question is undoubtedly associated with an ancillary problem pertaining to the determination of the method by which Bengal should be enabled to curtail her annual liabilities by developing her own resources. Surely she would not find it possible to dispense altogether with imports from other provinces, at least in respect of those articles, the production or manufacture of which in Bengal is handicapped by some natural disadvantages. But still, there are some other articles, which can be manufactured in Bengal and to which she should turn for attaining self-sufficiency with a view to improve her economic position. Such self-sufficiency should be attainable at least in respect of piece-goods, salt and raw cotton, if only the necessary degree of interest, energy, and determination of the people of the Province and the Government be brought to bear on the same. The potential scope for improvement to be secured to Bengal by this method is great indeed, as the attainment of self-sufficiency in respect of the three articles alone would enable this Province to effect a saving to the tune of 6·58 crores.

Sunyavada in Sabara-Bhasya

By Ganganatha Jha (Allahabad).

There has been some confusion of thought in regard to the exact position of the two sections which have been called by the editors from ancient times, *Nirālambanavāda* and *Śūnyavāda;* which has led to the idea (*a*) that the portion of the *Bhāṣya* preceding the words *Śūnyas tu* deals with the doctrine of Idealism that there is no real object in the external world, hence all cognition is baseless,—and (*b*) that with the words *Śūnyas tu* the *Bhāṣya* introduces the doctrine of Nihilism, that nothing, not even Idea, exists. But this interpretation of the *Bhāṣya* is entirely wrong. From the last verse of the so-called *Śūnyavāda* section of the *Ślokavārtika* it is clear that the whole of that section is meant to establish the reality of the external object, in confutation of the doctrine of Idealism, and the only argument in refutation of the doctrine of Nihilism is that "when the reality of the external object cannot be denied, it is all the more unreasonable to deny the reality of the Idea or Cognition"; so that the Mādhyamika doctrine of *Śūnyavāda* is not what is meant to be directly introduced or attacked in the *Bhāṣya* beginning with the word *Śūnyas tu,* which, in reality, is only a continuation of the refutation of the doctrine that there is no real external object. This is made clear by the section of the *Bhāṣya* concluding with the words *Ato na nirālambanaḥ pratyayaḥ,* for this reason, cognition is not devoid of a real substratum. The *Bṛhatī* clearly says, "It should not be thought that the section of the *Bhāṣya* preceding the word *Śūnyas tu* has refuted the denial of the real external substratum of Cognitions, and the section beginning with *Śūnyas tu* proceeds to deal with the Mādhyamika doctrine of Nihilism: because the *śūnyatā,* 'voidness', spoken of in the *Bhāṣya* is meant to be the voidness of

the Cognition itself—i.e. the cognition is devoid of a real subject,—and it is not that the Idea or Cognition itself is denied."—According to Kumārila (*Ślokvārtika, Śūnyavāda,* verse 3), the question discussed in the *Bhāṣya* beginning with *Śūnyas tu* is—"Is it a fact that Cognition is able to function only when such objects as the pillar and the like have an existence in the external world—or is it that Cognition rests in itself as the object cognised, and not in any object extraneous to itself"? So according to this also, the *Bhāṣya* does not introduce here a discussion of the Mādhyamika doctrine of Nihilism.

Photosynthesis in Laboratory

By Muzaffaruddin Qureshi (Hyderabad).

Photosynthesis or the process of carbon-assimilation taking place in plants under the influence of solar energy is one of the most fundamental processes of nature. Its importance is too obvious to need any comment. Our own life depends ultimately on the great variety of substances manufactured by the plant with the help of solar energy, namely carbohydrates, oils, proteins, glucosides, vitamins etc. How this process takes place in the laboratory of the green leaf is one of those fascinating problems, which have so far defied the ingenuity of scientific workers. A number of hypotheses, some of which are modifications of the so-called formaldehyde theory, originally put forward by Baeyer, have been advanced to explain the mechanism by which this important change, i.e., the conversion of carbon dioxide into carbohydrates is brought about in nature. But none of these, not even the formaldehyde theory, which has appealed to many by reason of its striking simplicity, satisfies the conditions of an established hypothesis. Photosynthesis is still a mystery. Nonetheless, these hypotheses have served a very useful purpose in stimulating experimental work, particularly in the direction of the artificial photo-reduction of carbon dioxide to formaldehyde and carbohydrates. It is the object of this short paper to give a brief summary of the work done in this direction. This will include only such atempts as have been made to reduce carbon dioxide in aqueous solutions with the help of visible and ultraviolet light and with and without the presence of catalysts or absorbing surfaces. Those investigations in which atomic or nascent hydrogen has been employed to reduce carbon dioxide are excluded from this survey, for the simple reason that the conditions are not the same as in the

natural process. There is no definite experimental evidence to the effect that nascent hydrogen is produced in the leaf as the result of illumination by the rays of the sun. Moreover, the reduction of carbon dioxide by means of nascent hydrogen is an ordinary dark reaction which does not seem to be influenced by light.[1]

The first definite attempt to reduce carbon dioxide in aqueous solution in the absence of hydrogen was made by Usher and Priestley,[2] who claimed to have obtained formaldehyde by exposing aqueous solutions of carbon dioxide in quartz tubes to ultraviolet light. Moore and Webster[3] found formaldehyde when aqueous solution of carbon idoxide were exposed to light in the presence of various inorganic catalyst, such as ferric oxide, uranic salts etc. Baly and Heilborn and Barker[4] also detected formaldehye on exposing aqueous solutions of carbon dioxide to ultraviolet light. When rays of 200 $\mu\mu$ were employed, formaldehyde was found, but with rays of 290 $\mu\mu$ and more it polymerised to reducing sugars. The experiments of Moore and Webster and Baly and Heilborn were repeated by Spoehr,[5] Baur and Rebman[6] and Baur and Buchi,[7] but no formaldehyde was detected. Porter and Ramsperger[8] repeated the experiments taking every possible care to prevent contamination of the materials. No trace of aldehyde or reducing sugars was obtained even after 60 hours' exposure. Baly and his co-workers[9] in a subsequent publication mention hexose as the primary product of the action of ultraviolet light on aqueous solutions of carbon dioxide, which is produced in very small quantities as the result of the establishment of a photo-stationary state represented by the following equation :—

$$6CO_2 + 6H_2O \rightleftharpoons C_6H_{12}O_6 + 6O_2$$

The presence of oxidisable impurities would favour the forward reaction and more hexose will appear, which will further decompose in ultraviolet light to give detectable quantities of formaldehyde. Inspite of the ingenuity of the explanation, the question of the source of formaldehyde detected in Baly's experiments still remains undecided. It remains to be proved that the formaldehyde obtained in these experiments was the result of the

photo-chemical decomposition of hexose and not of the oxidisable impurities themselves.

The writer in collaboration with Mr. S. S. Mohammad[10] has also performed some experiments in this connection. In one series of experiments conductivity water, through which a rapid current of carbon dioxide was passed, surrounded a mercury-vapour lamp of the immersion type. Exposures up to 24 hours failed to reveal any trace of formaldehyde or sugars. It may, however, be mentioned that in one of the experiments a positive test for carbohydrates was obtained, but this was later found to be due to small particles of cork which had fallen down into the solution. When experiments were repeated without the cork, no carbohydrate was detected. This incident throws some light on the probable causes of discrepancy in the literature cited above. In order to guard against the possibility of formaldehyde decomposing as soon as it is formed, another series of experiments were performed using mono-chromatic radiations of 313 $\mu\mu$, and 254 $\mu\mu$ respectively. In no case formaldehyde or sugar was detected.

Dhar and Sanyal[11] claimed to have obtained formaldehyde by passing carbon dioxide through pure water and solutions of methyl orange, methylene blue, chlorophyll, ferric chloride, uranyl salts etc. in the tropical sun-light. Burk in America,[12] using sun-light of varying intensity failed to substantiate these results. Dhar and Gopal Rao[13] repeated their experiments and confirmed their original claims. We[14] have tried to seek formaldehyde under the influence of sun-light in Hyderabad, but it has once again evaded us. Experiments were performed with and without catalysts, in sun-light as well as artificial light from an incandescent lamp of 500 c.p. with special attention to the purity of the materials employed and the arrangement of the apparatus. A large number of experiments was performed, but not a single experiment yielded positive tests for formaldehyde or sugar. This led us to undertake a thorough examination of the various tests employed for the detection of formaldehyde. This examination revealed that Buchanan-Schryver test is the most sensitive and reliable of all the

tests. It is capable of detecting one part formaldehyde in 1,000,000 parts water within one second, while Schiff's reagent does not develop colour with the same concentration of formaldehyde even after the expiry of several hours. Another point to be noted in this connection is the influence of the varying quantities of hydrochloric acid on the development of colour in the Schryver test. We have been able to determine the optimum concentration of hydrochloric acid with extremely dilute solutions of formaldehyde, varying the amount of hydrochloric acid added and noting the time required for the appearance of pink colour. It was found that for a 10 c. c. solution of formaldehyde containing 1 part in 10^7 water, the time required for the appearance of colour decreases with increase in the quantity of acid, until it is about one second for 3 c.c. of hydrochloric acid. On increasing the quantity of acid beyond 3 c.c., the time required for the appearance of colour becomes nearly constant. In these experiments, control tests were carried out with pure conductivity and distilled water. It may also be pointed out that even with conductivity water light purple colour develops after 24 hours. With Schiff's reagent the influence of hydrochloric acid shows itself in a different way. It retards the appearance of colour, but at the same time if hyrodrochloric acid is absent or present in very low concentration, colour appears even with simple water. We found that the amount of hydrochloric acid added should not be less than 1 c.c. for 10 c.c. of a solution containing 1 part formaldehyde in 500,000 parts water.

It is known that gases become extraordinary active when they are adsorbed on a surface. Something similar happens when they are mechanically broken up into fine bubble on being forced through filter-thimbles, as shown by Zenghlis[15] in a beautiful series of experiments. Hydrogen and carbon dioxide, in this condition, form complex organic compounds when exposed to ultraviolet light. From such considerations and also from analogy of the natural process, which is undoubtedly a heterogenous reaction. Baly was led to the idea that a surface capable of adsorbing carbon dioxide might be helpful in promoting the photochemical reduction of carbon dioxide. The results of experiments conducted on these

lines by Baly and his co-workers[16] are set out in three papers published in the Proceedings of the Royal Society.

In the words of Baly, when an insoluble powder, capable of adsorbing carbon dioxide on its surface, is suspended in water through which is maintained a stream of carbon dioxide and the whole is exposed to ultraviolet light, complex organic compounds of the nature of carbohyrdates are formed. These may be recovered by evaporation of solution after removal of the insoluble powder. The powders used in ultraviolet light were aluminium powder, barium sulphate, freshly prepared aluminium hydroxide and the basic carbonates of aluminium, magnesium and zinc. The quantity of organic matter obtained by exposing 720 c.c. of water containing the powder to the light of a 220 volt U-shaped quartz lamp at a distance of 6 cm. for two hours, was about 0.02 gm. It charred readily when heated alone or with concentrated sulphuric acid, reduced Benedict's solution after hydrolysis with hydrochloric acid, gave Molisch reaction and formed a solid osazone. Similar results were obtained by the use of coloured powders and the visible light. The powders used were basic carbonates of nickel and cobalt. After an exposure of two or three hours to the light of an ordinary tungsten lamp, a gummy residue was obtained which gave all the tests for carbohydrates. The yield of organic matter for equal areas of the suspension was greater in this case than in previous experiments, where white powder and ultraviolet light were employed. It was further discovered that intense and prolonged illumination leads to the poisoning of the surface and reduced rates of photosynthesis. With complete poisoning photosynthesis ceases and carbohydrates begin to decompose.

The carbonates were prepared by adding a cold solution of cobalt or nickel nitrate to a cold solution of potassium carbonate slightly in excess. The precipitate was repeatedly washed with distilled water, ground with a small quantity of water, steamed and then filtered and washed, until it was completely free from alkali. The powder so prepared rarely gave good results. It required activation, which was achieved either by heating the dry powder at 120°-140° for 20 to 30 minutes or exposing it to white

light for 30 minutes. In later experiments[17] nickel carbonate prepared electrolytically and activated by exposure to white light for six hours was employed. Very rigid precautions were taken against the possible presence of organic impurities in the materials employed. Control experiments carried out exactly under the same conditions but protected from light gave negative results. Control tests alone numbered more than two hundred. In order to get a greater amount of active surface, Baly conceived the idea of depositing basic carbonate of nickel and carbonate on aluminated kieselguhr. The experiments perfomed with these supported catalysts have been reported by Baly in the Discussions of Faraday Society, held in 1931.[18] Baly claims to have obtained 0.0025 gm. of photosynthesised organic matter per gram of powder in two hours exposure. Ferric and chromium hydroxide supported on aluminated kieselguhr have also been tried and found active photosynthetically.

The anouncement of these results has led those who are interested in this field of research to repeat the experiments of Baly and his co-workers. Highly interesting and important though they are, they still lack confirmation. Bell in England[19] on repeating the work and taking every possible precaution to avoid contamination of the materials employed, fails to obtain any indication of photosynthesis. Paul Scheile Jr. in America[20] comes to the same results, although he has taken all the precautions mentioned by Baly in his papers referred to above. We have also repeated these experiments with all possible precautions about the purity of the materials, particularly the carbon dioxide employed. So far as the experiments with carbonates of nickel and cobalt prepared chemically by the method given by Baly are concerned, the results are all negative. There is practically no difference between the residues obtained from suspensions exposed to light of different intensities and those kept in the dark as controls. Further experiments with nickel carbonate prepared electrolytically and activated by exposure to light are in progress and will be reported in due course.

From what has been mentioned above, it is quite clear that

up to the present moment, all attempts to reduce carbon dioxide in aqueous solution to formaldehyde or sugars with the help of the radiant energy have resulted in complete failure or at best in unconfirmed claims. One of the causes of failure is the selection of experimental conditions regardless of the fact whether the radiant energy employed is capable of bringing about the desired change. This is particularly true of those experiments in which ultraviolet light has been employed to reduce carbon dioxide in aqueous solutions in the absence of any adsorbing surface. Theoretical considerations lead to the result that radiations of wave-legth longer than 255 $\mu\mu$ do not contain sufficient amount of energy to reduce carbon dioxide to formaldehyde or sugar. Next experiments should, therefore, be conducted with radiations of wave-lengths shorter than 255 $\mu\mu$, and to reduce the chances of failure monochromatic radiations should be employed. With regard to those experiments in which suspensions of adsorbing powders and visible light have been employed, the case is a little different. Here, it is believed that a carbonic acid molecule receives a double activation, first throguh adsorption on the surface and afterwards through the adsorption of radiant energy. Taking into consideration the fact that photosynthesis in vivo is, to all appearance, a heterogeneous reaction taking place on the surface of the chloroplast in the leaves, this mode of attack is full of possibilities, provided one succeeds in obtaining surfaces approaching to some extent in activity the surfaces existing in the cells of the leaf.

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Appreciation on behalf of the Education Department, Bengal communicated by the Director of Public Instruction

Sir Prafulla Chandra Ray joined the Presidency College, Calcutta, as a Professor of Chemistry in the year 1889, and when he published his first paper on the Nitrites of Mercury in the Journal of the London Chemical Society in the year 1896, the scientific world suddenly and with a pleasant surprise became conscious of the fact that the long and gloomy night of India's inactivity and inertness in the domain of Science was fast drawing to an end, and that India had also something to contribute to the glorious achievements of Modern Science which was being pursued with unique energy, perseverance and devotion by the western nations. It not only marked the end of India's dark age of ignorance and stagnation, but also clearly indicated the happy re-awakening of the genius of originality as well as of creative energy in a people whose natural growth and development had unfortunately become arrested in course of time.

His 'History of Hindu Chemistry' which is a masterly production of his profound scholarship, untiring energy and indefatigable labours, and his valuable contributions to Chemical Science, then followed in quick succession and in kaleidoscopic colour, and his originality, great personality, saintly character and unique devotion to Science soon created in the Chemistry Department of the Presidency College an atmosphere of scientific research and unceasing quest for scientific truth, which fostered the rapid growth and development of an Indian School of young investigators in the field of Chemistry, who have now succeeded in securing due recognition in the scientific world. Prafulla Chandra worked in the Chemical Laboratory of the Presidency College for over twenty-

seven years, turning out every year two or three young and enthusiastic workers in the field of Science, well-equipped and well-trained for original investigation, imbued with the spirit of research by his master mind, and keen on devoting themselves to the pursuit of Science.

His many-sided activities and researches in the domain of Chemistry contributed not a little to raise both the Presidency College and the University of Calcutta in the estimation of the world outside as important centres of advanced learning and research. His name will also go down to posterity as the founder of important chemical industries in Bengal, which are indebted so largely to him for their development. He will always be remembered as an ideal of plain living and high thinking, a great savant in the sphere of Science, an inspiring teacher in the educational circle, a kindly benefactor of students, a constant friend of suffering humanity, and, above all, as a devoted son of Mother India possessing such wealth of culture and strength of character as alone will go far towards ensuring India's rightful place in the hierarchy of nations.

May God grant him many more years of health and activity to continue to teach and guide the youths in the path of intellectual greatness, scientific research, true assimilation of the East and the West and disinterested service to humanity!

R. N. Sen

Principal, Krishnagar College.

The Racial Origins of the Bengali

By B. S. Guha (Calcutta).

The racial classification of the people of Bengal on a scientific basis was first attempted by the late Sir Herbert Risley in 1891 in his preliminary edition of the "The Tribes and Castes of Bengal". In this work he advanced his well known theories of the origins of the Inidan people and characterised the Bengali as "a blend of the Mongolian and Dravidian elements with a strain of Indo-Aryan blood in the higher groups". The term "Mongolo-Dravidian" was applied to this composite type and the bulk of Orissa and the whole of Bengal extending to the Himalayas in the north, Assam on the east, and the hilly country of Chota Nagpur on the west was suggested as its habitat. The people selected as representatives of this type were the Brahmins, Kayasthas, the Rajbansi Maghs of Chittagong, the Mals of Bankura, Midnapur, and the Kochs of Jalpaiguri and Rangpur.[1]

In order to determine the truth or otherwise of Risley's theories two things have mainly to be taken into consideration, namely :—

(1) How far can the groups mentioned above be regarded as representatives of the Bengali people and

(2) the amount of truth underlying Risley's interpretations.

There is no doubt that the Brahmins and Kayasthas constitute the upper classes of the Bengali people but can we say the same of the remaining three tribes selected by Risley? For instance the Rajbansi Magh who lives in the hill tracts of Chittagong and is one of the three endogamous divisions of the Magh tribe originally came from Arakan and are really Indo-Chinese in race.[2] Their social

1. The People of India by Sir H. Risley (Calcutta 1915), pp. 33-42.
2. The Tribes and Castes of Bengal by H. Risely, vol. II (Cal. 1891), pp. 28-30.

organisation and clan names bear unmistakable proofs of their origin and if further corroboration is necessary it is amply given by such names as, Ahong, Sepotang, Pongdung, Thapasu, Thainga etc.,[3] of the men measured under Risley's instructions at Rangamati (headquarters of the Hill Tracts) that though long settled in the Chittagong district they still retain their tribal character.

Similarly the Mals now settled in Bankura, Birbhum etc., as Risley himself admits, migrated from the Rajmahal Hills and are ethnically identical with the Mal Paharias, Males etc. of the Santal Parganas.[4]

Lastly about the Rajbansi Kochs of North Bengal it is well known that they are the descendants of the great Koch tribe who conquered North Bengal. Most of the men measured by Risley have names such as Paia, Lethru, Lobu, Alinga, Enna, Tandu, Lobai [5] etc. which are certainly not Bengali. Col. Waddel who himself measured a large number describes them as "distinctly mongoloid".[6]

From the foregoing statements it will appear that all these tribes are admittedly of foreign origin though now settled for sometime in the outlying districts of Bengal and cannot be regarded as true samples of the Bengali population. Any conclusions based on measurements of these people therefore are *ipso facto* inapplicable to the latter.

When the somatic characters are considered it is found that the Mals, like their kinsmen the Mal Paharias and Males of the Santal Parganas belong to what in the absence of a better term has been called the "Proto-Australoid" race, with short stature, long head and very broad and depressed nose. The Rajbansi Maghs on the other hand are broad-headed with flat nose and very highly developed check bones. The absence of hair on the face, and body and the half open slanting eye with epicanthic fold are unmistakable

3. Tribes and Castes of Bengal—Anthropometric data, vol. I (Cal. 1891), pp. 206-212.
4. Tribes and Castes of Bengal, vol. 2, p. 46.
5. Anthropometric data, vol. I, pp. 166-171.
6. J.A.S.B., vol. lxix, iii p. 190.

characteristics of the Mongoloid races. The Kochs of Northern Bengal occupy an intermediate position so far as the head-shape is concerned but in their facial features they share the Mongoloid traits of the Magh.

A comparison of the Brahmins and Kayasthas of Bengal with the above shows (1) that unlike the first, these two tend towards round-headedness and possess a long prominent nose; the mean nasal index being 70·35 (Leptorhine) against 84·7 (Platyrhine) of the Mals. (2) Though less broad-headed than the Maghs they have neither their depressed broad nose (N. I. 82·7) nor the flatness of the face; the mean bizygomatic breadth being 128 mm. against 137·8 of the latter and 132 mm. of the Koch. By no known laws of human heredity could miscegenation between these two races with flat, broad nose and face give rise to leptorrhiny of the Brahmins and Kayasthas of Bengal. Besides the special traits which are distinctive of the Mongoloid races, namely, paucity of facial and bodily hair, the presence of a fold covering the inner canthus of the eye are not characteristic of the former. The Bengali type as represented by the Brahmins and Kayasthas, therefore, could not be derived from admixture of the tribes mentioned by Risley. Its kinship and origins must be sought elsewhere.

A survey of the physical characters of the present population of India shows that all along the western coast from Guzrat down to Coorg there is a concentration of brachycephalic Alpine type. This element is predominant among the Guzrati, Marathi, Kanarese and Coorgi.

From the facts at our disposal this brachycephalic element does not appear to have penetrated into Malabar but was deflected slightly eastwards to Tamil Nadu in its movements down the south of the Deccan plateau. This movement was apparently directed southwestwards in the main; its presence among the Telegu people of the north-eastern coast being not strongly felt.

In Upper India, the whole of the Punjab and the Gangetic valley up to Benares do not disclose the presence of this type in any appreciable degree but from Behar eastwards we find the gradual

increase of a broad-headed element whose maximum intensity is found in the population of Bengal.

In attempting to account for this bracycephalic factor in the western and eastern parts of India, Risely supposed the presence of a Mongolian element in the East and a Scythian element in the West. There is no historical evidence for the existence of the former in the Deccan, and as we have just seen it cannot be explained by the presence of a mongoloid element in Bengal.

In a very suggestive paper in the Indian Antiquary[7] Prof. D. R. Bhandarkar has shown the identity of a large number of surnames of the Nagar Brahmins of Guzrat and the Kayasthas of Bengal such as Mira, Ghose, Dutta, Nag, Pal etc. A comparison of the physical characters of these two castes therefore is instructive. The Anthropometric measurements taken by the late B. A. Gupte[8] under the directions of Risley show that the mean stature of the Nagar Brahmins is 1643 mm. against 1636 mm. of the Bengali Kayasthas, i.e. a difference of only 7 mm. or less than one-third of an inch. The mean cephalic and nasal indices of the former are 79·7 and 73·1 against 78·2 and 70·3 of the latter. Further when the data are analysed it is found that 63% of the Nagar Brahmins are bracycephalic and 53% leptorhine against 60% brachycephalic and 71% leptorhine of the Bengali Kayasthas.

The obvious explanation of this kinship, physical and cultural between the people of Guzrat and Bengal would no doubt have occurred to Risley if (1) he had taken into consideration the head form of the Mongoloid tribes bordering on Bengal and (2) the possibility of a racial bridge between the two regions through the Central Indian Plateau.

(1) An examination of the physical characters of the Mongoloid tribes along the boundaries of Bengal shows that the tribes living in the Brahmaputra Valley, and the Garo, Lushai and Naga Hills strongly incline towards dolichocephaly; the brachy element predominating along the Sikkim, Nepal borders and in the Chitta-

7. Indian Antiquary 1911, pp. 7-37.
8. Anthropometric data from Bombay, Cal. 1907.

gong Hill Tracts. In Bengal the concentration of the broad-headed element is in the Central or Deltaic region with gradual decrease towards the north and east. The origin of the Bengali brachycephaly therefore cannot be sought in them.

(2) In Risley's days not much was known of the somatic characters of the inhabitants of Central India and it was thought that the prevailing type was what Risley called "Dravidian", i.e. the Veddaic or Proto-australoid type as represented by the Mals and Mal Paharias of Manbhum, Singbhum etc.

In a recent survey undertaken by the present writer (a full account of which will be published later) to trace the possible routes of migration between the west and the east, remnants of brachycephalic elements were found throughout the Malwan Plateau as far as Rewa i.e., 83° East longitude, and from the evidence collected, there is no reason to doubt the existence of a racial bridge at one time, through the Central Indian highlands.

The possibility of the occurrence of a second route from the Deccan northwards into Bengal through Andhra and Orissa does not appear to be very strong, for the reason already mentioned that the main drive of the brachycephalic element through the Indian peninsula appeared to have gone south-east to the Tamil country leaving the Andhras of the north comparatively untouched.

If the racial history of Bengal is linked with that of Guzrat in the way indicated above much of the perplexities of the situation will have disappeared and no recourse need be had to a supposed Mongoloid strain to explain the brachycephalic element among the Bengalis.

The Spirit of Exploration and Adventure in Ancient India

By R. C. Majumdar (Dacca).

An indomitable and reckless spirit of exploration and adventure is a characteristic feature of all progressive nations. The recent attempts to explore the Polar regions and the Everest are typical examples of that spirit. It is now regarded as a monopoly of European nations, and its beginnings may be traced to the wonderful geographical discoveries of Columbus, Cook and many others. The Indians are lamentably lacking in this spirit to-day and most people are apt to suppose that they have always been so. This is, however, contradicted by known facts of history, and I propose to bring together in this short paper a few interesting data to refute this erroneous view.

It is now an established fact that the Hindus had explored, among others, the whole of the Pacific regions up to New Guinea, during the early centuries of the Christian era. We may easily imagine the dangers and difficulties of navigation in uncharted seas by means of primitive wooden boats. The lure of the unknown must have been strong indeed, in order to induce the Indians to brave these perils of the sea. What these perils are has been very vividly described in many ancient folk-stories preserved in Hindu and Buddhist literature. It is not difficult to look beyond the imaginary framework of these stories and catch a glimpse of the reckless spirit of venture that forms the real background of these works of fiction. Fortunately, we possess at least one sober account of an eye-witness that may give us some idea of the dangers and difficulties cheerfully faced by Indians times without number in their enthusiasm to explore the unknown.

The eye-witness is no less a renowned figure than the Chinese

pilgrim Fa-hien. He "took passage in a large merchantman, on board of which there were more than 200 men, and to which was attached by a rope a smaller vessel, as a provision against damage or injury to the large one from the perils of the navigation. With a favourable wind, they proceeded eastward for three days, and then they encountered a great wind. The vessel sprang a leak and the water came in. The merchants wished to go to the small vessel; but the men on board it, fearing that too many would come, cut the connecting rope. The merchants were greatly alarmed, feeling their risk of instant death. Afraid that the vessel would fill, they took their bulky goods and threw them into the water. Fa-hien also took his pitcher and washing-basin, with some other articles, and cast them into the sea; but fearing that the merchants would cast overboard his books and images, he could only think with all his heart of Avalokitesvara Buddha and commit his life to (the protection of) the church of the land of Han, (saying in effect), 'I have travelled far in search of our Law. Let me, by your dread and supernatural (power), return from my wanderings, and reach my resting place.'

"In this way the tempest continued day and night, till on the thirteenth day the ship was carried to the side of an island, where on the ebbing of the tide, the place of the leak was discovered, and it was stopped, on which the voyage was resumed. On the sea (hereabouts) there are many pirates, to meet with whom is speedy death. The great ocean spreads out, a boundless expanse. There is no knowing east or west; only by observing the sun, moon and stars was it possible to go forward. If the weather were dark and rainy, (the ship) went as she was carried by the wind, without any definite course. In the darkness of the night, only the great waves were to be seen, breaking on one another, and emitting a brightness like that of fire, with huge turtles and other monsters of the deep (all about). The merchants were full of terror, not knowing where they were going. The sea was deep and bottomless, and there was no place where they could drop anchor and stop. But when the sky became clear, they could tell east and west, and (the ship) again went forward in the right direc-

tion. If she had come on any hidden rock, there would have been no way of escape.

"After proceeding in this way for rather more than ninety days, they arrived at a country called Java-dvipa, where various forms of error and Brahmanism are flourishing, while Buddhism in it is not worth speaking of. After staying there for five months, (Fa-hien) again embarked in another large merchantman, which also had on board more than 200 men. They carried provisions for fifty days, and commenced the voyage on the sixteenth day of the fourth month.

"Fa-hien kept his retreat on board the ship. They took a course to the north-east, intending to reach Kwang-chow. After more than a month, when the night-drum had sounded the second watch, they encountered a black wind and tempestuous rain, which threw the merchants and passengers into consternation. Fa-hien again with all his heart directed his thoughts to Avalokitesvara (Buddha) and the monkish communities of the land of Han; and, through their dread and mysterious protection, was preserved to day-break. After day-break, the Brahmans deliberated together and said, 'It is having this Śramana (Buddhist *bhikshu*) on board which has occasioned our misfortune and brought us this great and bitter suffering. Let us land the *bhikshu* (monk) and place him on some island-shore. We must not for the sake of one man allow ourselves to be exposed to such imminent peril'. A patron of Fa-hien, however, said to them, 'If you land the *bhikshu*, you must at the same time land me; and if you do not, then you must kill me. If you land this Śramana, when I get to the land of Han, I will go to the king, and inform against you. The king also reveres and believes the Law of Buddha, and honours the *bhikshus*.' The merchants hereupon were perplexed, and did not dare immediately to land (Fa-hien).

"At this time the sky continued very dark and gloomy, and the sailing-masters loked at one another and made mistakes. More than seventy days passed (from their leaving Java), and the provisions and water were nearly exhausted. They used the salt-water of the sea for cooking, and carefully divided the (fresh) water,

each man getting two pints. Soon the whole was nearly gone, and the merchants took counsel and said, 'Aṭ the ordinary rate of sailing we ought to have reached Kwang-chow, and now the time is passed by many days;—must we not have held a wrong course?' Immediately they directed the ship to the north-east, looking out for land; and after sailing day and night for twelve days, they reached the shore."

This vivid description, to which others might be easily added, would give us some insight into the perils and hardships of the sea-voyage, even after it had been regularly practised for more than five hundred years. But the difficulties did not cease with the sea-voyage. Beyond the unknown sea lay the *terra incognita* which was their next object of exploration. The terrors and dangers of this land-route are referred to in a Buddhist work called Niddesa, a commentary on Sutta-nipāta, and a text belonging to the Pali canon. While commenting on the word "*pariḳissati*" (is tormented) the commentator takes the opportunity to refer to the various kinds of torments to which men are subjected. Among others he mentions, how, overpowered by lusts and desires, and with a view to seek enjoyment, men cross the ocean in boats, suffering from storm, heat and cold, and mosquito and snake-bites, etc. Then follows a long list of countries which these men visit after this ardous sea-voyage. The list includes a number of sea-ports from Java on the east to Alexandria on the west. After reaching these sea-ports men seek to reach the interior and the commentator gives a list of the difficult routes which they have to follow. These are:

(1) Marukāntāra (=মরুকান্তার)
(2) Jannupatha (=জন্নুপথ)
(3) Ajapatha (=অজ পথ)
(4) Meṇḍhapatha (=মেণ্ড পথ)
(5) Śankupatha (=শঙ্কু পথ)
(6) Chattapatha (=ছত্র পথ)
(7) Vaṃśapatha (=বংশ পথ)
(8) Śakunapatha (=শকুন পথ)
(9) Musikapatha (=মুষিক পথ)

(10) Daripatha (=দরীপথ)
(11) Vettadhara (=বেত্রধার)

These terms would at first appear somewhat enigmatic. But their precise meaning becomes clear partly by a further commentary (saddhammappajotikā) and partly by the occurrence of some of them in the very interesting story of the merchant Sānudāsa as narrated in Bṛhatkathā-śloka-saṃgraha. We begin with this study first and quote the summary from La Cote's Essay on Guṇāḍhya.

"Sānudāsa joins the gang of the adventurer, Ācera, who is preparing an expedition to the land of Gold (Suvarṇabhūmi = Far East). They cross the sea and land at the foot of a mountain. They climb up to the top by catching hold of creepers. This is the "creepers path." On the plateau there is a river which changes into stone everything that falls into it. They cross it by holding on to the bamboos which overhang the banks. This is 'the bamboos path." Further on they meet a narrow path between two precipices. They light a fire with wet branches; the smoke attracts some Kirātas who come and propose to sell them some goats; the adventurers get on those goats, the only animals sure-footed enough to be able to follow the narrow edge without feeling giddy. This is "the goats path." The adventurers do not come to the end of it without some difficulty as another gang is approaching from the opposite direction. A struggle ensues but Ācera's troops are able to pass through after having thrown their enemies into the ravines. Sānudāsa begins to feel indignant at the fierceness of the gold-seekers. Ācera orders his followers to slay the goats and to put on their skins with the inside out. Huge birds will mistake those men for a heap of raw meat, come and carry them away to their aerie. It is there the gold is! Sānudāsa attempts to save the goat he was riding but his companions are pitiless. Everything takes place as Ācera had foretold but the bird which carries off Sānudāsa is attacked by another bird which atempts to steal his prey. The goat's skin bursts open and Sānudāsa falls in a tank which is in the heart of a luxuriant forest. The next day he comes to a river the banks of which are of golden

sand; near by there is a hermitage from which a hermit comes out."

The story thus explains Ajapatha (No. 3) and Vaṃśapatha (7) and the episode of Sānudāsa being carried aloft by a huge bird evidently explains the Śakunapatha (8). Menḍhapatha (4) obviously is to be explained in the same way as Ajapatha, substituting ram for a goat. The Vetrapatha is added in the story and may correspond to Vettadhara or Vettacara (11).

The commentary explains Jannupatha (2) as the way where one has to crawl on knees and Marukāntāra, as a sandy desert where one has to travel at night by the guidance of stars alone. On Śankupatha it gives a long explanatory note, describing the means by which a man could ascend a mountain. An iron hook attached to a rope of skin is thrown up till the hook is fixed up in the mountain. Having climbed up the rope the man makes a hole in the hillside with a diamond-tipped iron instrument and fixes a spear. Having caught hold of this he detaches the hook and throws it aloft again, till it is again fixed up in the mountain. Then he ties the rope to the spear, and having caught hold of the rope with one hand strikes it by a hammer with the other hand till the spear is detached. Then he climbs up again, again fixes the spear and repeats the process till he ascends the top of the hill.

Chattapatha is explained in the commentary as the way where one jumps down from a precipice with an open parasol (Chatta = Chatra) made of skin, and descends slowly to the ground on account of the resistance of the air. In other words it involves the principles of *parachute*.

The Musikapatha (9) and Daripatha (10) are not explained by the commentary and cannot be exactly understood. They evidently refer to some process like tunnelling.

References to these extraordinary routes are not confined to the two texts mentioned above. They are met with in the Vimānavatthu, the Jātakas, Milinadpañha, Kātyāyana's Vārtika and Ganapāṭha. None of these, however, mentions a large number of them, and the Purānas alone add a new one, Khara-

patha, which is evidently to be explained in the same way as Aja-patha, substituting ass (Khara) for goat (aja).

It is to be noted that Kātyāyana associates these ways with merchants, and Milindapañho agrees in a way, substituting seekers of wealth for merchants. The Vimānavatthu definitely associates them with oversea countries, agreeing in this respect with Niddesa and Vṛhatkathāslokasaṃgraha. The Purānas also mention them in connection with countries outside India.

The references to these extraordinary routes in so many ancient texts constitute the most interesting evidence of the spirit of adventure in ancient India. The most note-worthy is the reference to Chattapatha. The explanation in the commentary that by using a skin-umbrella, one can jump down from a high precipice, and yet descend slowly because of the resistance it offers to air is most interesting as it shows an acquaintance with the principles of *parachute*.

Literature has justly been regarded as the echo of national life. Judged by this principle, the texts quoted above and the numerous folk-stories about merchants preserved in ancient Indian literature must be taken to imply that the spirit of exploration and adventure was a characteristic feature of ancient Indian life.[1]

1. The passage in Niddesa, quoted above, has been made the subject of a learned discussion by Prof. S. Levi, whose writings constitute the basis of this article (Cf. Etudes Asiatiques, vol. II, p. 1 ff.).

From His Old College

To-day the whole country is ringing in joyful celebration of the Seventieth birthday of our illustrious countryman, Acharyya Prafulla Chandra Ray. As a member of the Presidency College, Calcutta, I feel a special pleasure in joining my voice to this chorus of general rejoicings. We have the proud privilege of claiming the distinguished savant as an old boy of our college. It is here in our laboratories that he carried on his teaching and investigation work for 27 years and trained a devoted band of brilliant chemists, whose researches have excited the admiration of the scientific world.

Sir P. C. Ray's connection with Presidency College can be traced back to the late seventies of the last century. He had been for four years a student of the science department of the college before he started for England for the furtherance of his studies. He came back to the college in June 1889 as Assistant Professor of Chemistry. Our Chemical Laboratory was at that time housed in an old one-storeyed building on the north of the compound in which the old Hare School had been located. Some of the valuable researches of Dr. Ray were carried on in this earlier, humbler and unpretending laboratory. In those days the teaching of Chemistry even for the B.A. Course was comparatively elementary and no training in practical work was necessary. Gradually through the persistent efforts of Dr. Ray, backed by Sir A. Pedler, a new wing of the building was constructed and the laboratory was fitted up with necessary appliances.

Prafulla Chandra became the Professor of Chemistry in 1896. Under his inspiring guidance the Chemical Department of the Presidency College made large strides in the early part of

the present century. Attracted by the notable work that was being carried on more pupils joined in and the laboratory of Presidency College became the scene of lively chemical activity. Professor Ray grudged no trouble to help on the work of his pupils, and his valuable guidance enabled a large number of workers to develop ability for original research. Thus by training batches of brilliant chemists to supplement and continue his noble work, he has deservedly earned the title of the Father of the Indian School of Chemistry. It was he who bitterly deplored the intellectual torpor and stagnation of the country and it was quite in the fitness of things that to him should devolve the noble task of regenerating Indian Chemisry. In his monumental work, the History of Hindu Chemistry, he has shown how considerable were the attainments of ancient India in the field of science. And it is mainly through his efforts that the land of Nagarjuna has renewed activities which lay dormant for centuries.

Professor Ray retired from Government service shortly after his appointment as Palit Professor of Chemistry, Calcutta University in November 1916. Since then his official connection with his old College has ceased, but we sometimes have the honour of welcoming him to his old College on suitable occasions. His other activities will no doubt be recounted by other and more effective writers. And I conclude this brief statement of Sir P. C. Ray's activities in the Presidency College with a humble tribute of respect to the illustrious savant.

B. M. Sen

Principal, Presidency College.

Can Universities be Manufacturing Centres?

By N. N. Godbole (Benares).

The years 1931 and '32 should be looked upon as very glorious in the history of India, because in these two years, the seventieth anniversary of three of her noblest sons has been celebrated. In a country where the span of average life is limited to twenty-five years, it must be deemed a great providence of God that we are allowed to celebrate the birthday of our Great International poet, Rabindra Nath Tagore, Dharmatma Pt. Madan Mohan Malaviya, the Founder of the Benares Hindu University, and the great Guru of Indian Chemists, Sir P. C. Ray. To all of them we wish many happy years to come.

It was my privilege to contribute an article on the "Introduction of Applied Chemistry in Indian Universities" to the Malaviya Commemoration Volume, recently published. In this article I discussed briefly the scope, extent and nature of the subject of Applied Chemistry as it should be and as it actually is introduced in the Benares Hindu University, of which it undoubtedly forms a prominent and remarkable feature. It is proposed to discuss in this article whether "*Academic bodies like the Universities can and should be manufacturing centres* also"—a subject entirely suited to the memory of a chemist who has been as thoroughly practical as he has been theoretically deep in his researches.

As one who has been interested in the practical working of this question for the last few years, the first and the foremost difficulty in introducing manufacture in an academic body is one of "Atmosphere". As a rule, in an academic institution, the atmosphere is one of an easy-going attitude of mind, whereas in a manufacture, a rigid discipline is demanded as the work of the day has to be of longer duration besides being continuous. In other

words, there is the economic value of time. Holidays have to be few and far between in the manufacturing life, whereas in the academic life the holidays are supposed to foster the intellect by acting as a respite and tonic. Manufacturing life is more or less a mechenical life, whereas the University life is an intellectual one; in the former the efficiency is proportional to time, whereas in the latter it is perhaps inversely so. If therefore Universities have to be manufacturing centres, it must be clearly understood that the staff employed for educational purposes must be different from the staff employed for the commercial one; and the privileges of the two must be different. Obviously the manufacturing staff must enjoy special privileges not granted to the academic staff. The manufacturing operations are at times so continuous that they cannot be discontinued on any account even on Saturdays and Sundays. A University can declare a holiday on any day or at any hour it chooses, whereas a manufacturing concern is to get ready before the operations are so adjusted that it can declare a holiday. The trouble arises, therefore, when a manufacturing centre is located in and is under the guidance of an academic body. The two organisations must be different and must be conducted on different lines of administration. A special difficulty arises when Universities undertake manufacturing work, and that is with regard to the site. It is not always that a University is well located from an economic and industrial point of view. Indeed an institution well located from an academic point of view may be ill suited from the manufacturing point of view. This would mean an increase in the cost of production—a factor which hampers successful competition. It must be confessed that this is a positive disadvantage in some cases; but it must also be remembered at the same time that the University has to look upon its manufacturing concerns as being not so many money-making devices but as training institutions for providing practical training. Further we should note that this disadvantage is more than compensated by the free expert advice which is easily available in the University atmosphere.

A manufacturing concern to be successful must be based upon

a rigid procedure which does not admit of any elasticity as in an educational institution. The different processes involved in the finishing of an article presuppose definite intervals of time and the technicalities involved do not leave any choice of selection. A professor can dismiss his classes any time he chooses and can reassemble them any other time he likes; not so the manufacturer, as between two successful operations he cannot leave any interval he likes. Mechanical operations, therefore, tie down the specialist-in-charge to a definite series of operations, no matter whether it is early in the morning or late at night. The work has got to be done right through. This difference in the two mentalities of the academist and industrialist must clearly be borne in mind if Universities intend to take up manufacture also, as otherwise it would lead to a failure of the object in view. I am afraid, this has happened and is happening in some institutions in India and hence this note of warning. In many European countries, a number of the academic institutions and Universities that have specialised in giving industrial training are supported financially by industrialists and manufacturers. The object of such donors is to help the University in training specialists who will help them in turn to develop their own industries. It is, therefore, expected by such donors (and rightly too) that the Universities themselves do not form one more competitor to the already manufacturing private concerns outside. Such Universities, therefore, limit themselves only to the experimental part of the manufacture and not to commercial production. In India, however, the conidtions are so different that we have to adopt a different procedure altogether. We have neither the big factories nor the generous donors above refered to. Indeed in certain parts we have not even got any factories worth the name. When, therefore, Universities in India take to manufacture also they are doing nothing which is either unconstitutional or uneconomical. Many European visitors, interested in economics and manufacture, felt keenly interested in the experiment which is being tried in the Benares Hindu University where along with the teaching work manufacturing on a semi-large scale is being conducted. It must

be borne in mind that this experiment is looked upon as being unique inasmuch as conditions in India are so different from those that prevail in Europe and America as explained above.

It has been shown above that provided certain rigid measures are adopted and provided certain precautions are taken it is possible for academic bodies like Universities to become manufacturing centres also. It must be borne in mind, however, that Universities should not necessarily expect to make much profit out of such concerns. There is every probability that they may make money out of these concerns. The primary object of starting such concerns is demonstrative, secondly an attempt should be made to make them self-supporting, and lastly they may be made paying also. Our little experience in Benares has been encouraging and we expect that other Universities also will take up this experiment even with greater care and courage than we have been doing in Benares.

The one great reason why Universities should make a move in the matter is that there is a very large number of chemical industries which have not been taken up seriously as yet in India, e.g., the rubber industry, which can and should be taken up. Countries like Japan and Germany, which do not grow even one ounce of rubber, import all the necessary raw materials from outside and are to-day the leading manufatcurers of rubber goods. Why can we not do that in India? Besides raw material, capital and expert labour are the two necessities. It has been my experience that capitalists complain that they cannot get experts for starting new industries; on the other hand experts are available who are trained in foreign countries and who cannot furnish the necessary local data for starting factories under local conditions. Very often, therefore, when even foreign-returned experts have started new concerns in India, they have more often failed than succeeded because by the time they have gained an idea of the local conditions, and have trained the local labour and captured the local market, the capitalist has lost so much money and patience that factories have had to be closed down—just when they should have begun seriously. It should be made clear here

that the foreign-returned expert is not always to blame, because during the period of training in foreign countries, he gathers his knowledge in established firms which are running smoothly. When he returns to India he has to begin with everything and unless he is a man of exceptional ability, his chances of success are not many. Our Universities can and should be able to solve this difficulty. We have been spending up till now huge sums of our money in teaching pure Chemistry in our schools and colleges. Have we received anything tangible in return for all these heavy investments? Why should we not, therefore, divert at least half of this money in the channel of Applied Chemistry. It is quite easy for the University to get all the preliminary data regarding local conidtions with experiments conducted on a semi-large scale. This preliminary knowledge is so valuable and so necessary that it may almost be looked upon as the key to all success. A private capitalist has neither the foresight nor the patience to invest so much money to gather the preliminary knowledge. This is but human and the capitailst need not be blamed for being so. Universities are maintained out of public or Government funds and certainly they are justified in spending some of their money in gathering the fundamental data in the interests of public good. It will be seen, therefore, that the Universities are perfectly justified in launching an undertaking of this kind in the larger interests of the country.

Granted, therefore, that Universities in India take up the different industries in different provinces, they will be doing the most responsible part of the work by starting convenient units and collecting all the necessary data. Students, working in such educational institutions, will be fully benefitted as they will also collect all local information regarding raw materials, labour, cost of manufacture, etc.

It is true that Universities will have to take up the responsibility of selling the finished articles also. There is no reason why educational bodies should shirk this responsibility. Students trained in such an atmosphere have nothing to fear, because in addition to learning the details of the manufacture, they also learn

all about its economic working also. Capitalists would gladly welcome such young men becuse working with them does not involve any risk of capital.

The teaching in modern Universities has been very highly theoretical. Of course no one can deny the necessity of theory in carrying out all practical work. But unfortunately for India, teaching has been too much theoretical. The number of M.Sc.'s and D.Sc.'s in India in Chemistry is undoubtedly very large but how few of them are competent enough to manufacture even a boot-polish? It has been my happy experience that because of the accompaniment of the manufacturing side, teaching of Chemistry becomes a practical and a living science; both the teachers and the taught are benefitted by this combination. The practical teacher not only feels a personal delight in teaching but he also attracts the attention of his hearers by explaining to them the practical applications of Chemistry. As things stand to-day in India the teacher comes into the class prepared almost like a school-boy. The students also forget all their theoretical science the day the examination is over.

The few thoughts that have been put together by me in this article are the outcome of my experience of several years spent in the Department of Industrial Chemistry of the Benares Hindu University. I wish it were possible for every University in India to create similar facilities under its auspices so that more experience could be gathered under different surroundings. I have not the least doubt, that the time is coming when more Universities would also move in the same direction and when this happens the practicability of the success of this scheme can be established beyond doubt.

"One swallow does not make a summer", yet it must be said that the experiments tried in the Benares Hindu University should encourage other Universities of India to come forward and take up the experiment cheerfully and more vigorously. If this is done, what a glorious thing it would be to the student world!

The life of Sir. P. C. Ray is one of incessant action and devotion to duty. The service he has rendered to the cause

of the application of Chemistry stands pre-eminently as a beacon-light in the darkness of the poverty of India. May God spare him for many years more to come! May the teaching of his life bring forth a new future to the teaching of applied science in our Universities!

Rammohan Roy's Conception of Universal Religion

By Hiralal Haldar (Calcutta).

As the seventieth birthday of Sir P. C. Ray happens to nearly coincide with the centenary of the death of Rajah Rammohan Roy and as Sir P. C. Ray is a distinguished member of the community that owes its origin to the Rajah, it seems fitting that a paper, however short, on Rammohan Roy's conception of universal religion should be included in the volume published in commemoration of the birthday celebration.

One hundred years ago Rajah Rammohan Roy was working hard in this city to free the minds of his countrymen from the bondage of idolatry and superstitions of every kind, to remove the disabilities artificially imposed on men by caste, polygamy and child marriage, to save women from the inhuman practice of Suttee, to introduce Western education in the belief that it alone could open the eyes of the people of this country to their degraded condition and suggest to them better ways of life and to inculcate the principles of universal religion. It is interesting to note that Rammohan Roy was a contemporary of the great German philosopher, Hegel. Hegel was born in 1770, Rammohan Roy in 1772. Hegel was at the height of his fame and influence from 1814 to 1831. The same was the period of the Rajah's activities in Calcutta. Hegel's greatest work "The Science of Logic" was published in 1814-16. Exactly at the same time the Rajah's Commentary on the Vedanta Sutras was published. Hegel died suddenly of cholera in November 1831. Rammohan Roy also died suddenly of brain fever at Bristol in September 1833. He was born two years later and died two years later than Hegel. Both were about 61 years old when they died and both have revolutionised the world of thought, each in his own sphere. A remarkable

coincidence! But in one way the Rajah's greatness exceeds that of Hegel. The latter had every advantage of education and upbringing that enlightened society and surroundings could afford, but in Bengal the Rajah was enveloped in Cimmerian darkness. There was nothing to help, everything to discourage him. Nevertheless his genius enabled him to rise superior to obstacles of every kind and to attain to profundity of thought by no means inferior to that of Hegel. He is regarded by competent authorities as the founder of the science of comparative religion. That such a man should have arisen in the darkest age of Bengal is truly a marvel.

In this paper, I propose very briefly to touch upon some aspects of the universal religion preached by the Rajah. His conception of universal religion is not that it is a mere combination of elements collected from various sources and regarded as true by the individual judgment of the collector. It is not eclecticism. What is universal is the body of fundamental principles common to all historical religions. Baldly stated, these principles are that there is one Eternal Spirit who is the life and soul of the universe, that He is the source, the sustainer and preserver of all finite souls which are immortal, that the basis of spiritual life is moral culture and discipline and its highest expression the worship of God in spirit and truth. These he regards as the central teaching of all scriptures. But the universal is never apart from the particular. The essence of religious truth takes concrete form in different countries and ages in different ways according to varying historical conditions, habits, temperaments, ideas and idiosyncracies of men. The particular forms of religion are therefore necessarily diverse, but they are all expressions of the same underlying truth. The particular embodiment, however, is essential to universal religion. In insisting upon the correlativity of the universal and the particular in religion, Rammohan Roy is at one with his contemporary Hegel although, not knowing the German language, he had no acquaintance with his philosophy. Hinduism, Islamism and Christianity, the three religions with which he was most familiar and the scriptures of which he had studied in the original, he regards as three special forms of universal religion. They accentuate different

aspects of the religious life and each has its own element of strength. Hinduism is strong in the knowledge of the unity of God and man, Mahomedanism in the consciousness of the divine government of the world and the equality of all men with each other and Christianity in the sense of the brotherhood of man and the resulting ethical conception of life. But whatever may be the difference between the great historical religions, they are but varying expressions of the same eternal and immutable truths. In order to realise the universality of religion, it is not necessary for any one to exchange his own religion for another. All that he needs to do is to distinguish the essence from the accident, the inner core from the outer form. There is no doubt that the Rajah conceived Brahmoism not as an amalgam of truths culled from different religions but as the purified form of Hinduism. He fully realises that the several religions must grow by mutually influencing each other, there must be contact and assimilation between them, but each must develop along its own line. No religion is true only in part; each, in its purity, is the whole truth, but embodied in a particular form.

It is instructive briefly to compare the Rajah's view of universal religion with that of his contemporary, Hegel. According to Rammohan Roy the inner spirit of every great religion, freed from the impurities with which it is mixed up in course of time, is universal. According to Hegel universal religon is the form which it assumes in the culminating stage of its evolution when alone it adequately reveals its inner meaning. He regards the historical religions as only different stages in its growth. In the Rajah's view the chief religions of the world, although essentially the same in their purity, develop along different lines, but, according to Hegel, there is only a single line of development because religion is one and the same, and the successive stages in its evolution are the objective religions or religions which consist in the worship of natural objects, subjective or psychological religions and the Absolute religion which, in his view, is Christianity, not the Christianity of dogmas and creeds taken literally, but philosophically interpreted Christianity. The weak point of the Rajah's theory

is that he is apt to regard the later form of a religion as a falling off from its original purity. He does not see that in the case of a living and advancing people the posterior form of its religion, whatever may be the excrescences upon it, reveals the true meaning of religion more completely than its prior form. In his day it was not usual to apply the concept of evolution to human history. His great contemporary was strong precisely where he was weak.

The inter-dependence of all religions is due to the same fundamental truths being the common basis of them all. In virtue of the expression of the universal in the particular, it is possible for the adherent of a historical religion to rise above the limitations of his faith and to enter into the spirit of other religions, for a Hindu to be a Christian or Mahomedan in his outlook on life without ceasing to be a Hindu, and for a Christian or Mahomedan to look at things with the eyes of a Hindu without discarding his own particular form of belief. Such a universal man was Rammohan Roy. He had no difficulty in harmonising all religions from a point of view from which their differences are seen to be but particular embodiments of the same universal truth. Eliminate from the historical religions the impurities, the superstitions, the bigotry of priestcraft, the fanaticism of ignorance and the elements of racial jealousy and hatred and you discover the ground on which all can stand united in their common love of the one true God. Real and abiding unity of the adherents of different creeds can be obtained only on this basis. External diplomatic arrangements, the disposition to be tolerant of each other arising from political considerations, brotherly embrace prompted by the enthusiasm of a few days of festivities may lead to a temporary union, but will not bring about that brotherhood of man without which a genuine progress of the world is not possible.

Rammohan Roy was an ardent apostle of freedom. Nothing made him more indignant than the oppression of man by man. As is well known he rejoiced exceedingly whenever a body of men anywhere in the world broke their fetters of bondage. But with all his love of freedom he was not a mere individualist or a philosophical anarchist. He was greatly influenced by the rationalistic

literature of the eighteenth century, by the speculations of Hume, Holbach, Helvetius, Diderot, Rousseau, Voltaire, Volney and others, but his Hindu culture enabled him to see that the real right of man is not to do what he likes provided that he does not interfere with the same right of others, but so to exercise his powers as to contribute to the common good. While fully admitting that the guiding principle of life is reason, he had the clearness of vision to perceive that reason is not the property of an atomic individual but the spiritual bond which holds together the framework of society. The individual is rational only because he is rooted in society and shares in the universal reason embodied in its laws and institutions. He therefore insisted that in speculation as well as in action, the reason of the individual must be steadied through reconciliation with collective wisdom. Individualism must be harmonised with socialism. Neither in the interpretation of the scriptures nor in the regulation of conduct will it do to give unlimited scope to the individual's own sense of right and wrong. The progress of the individual is no doubt the criterion of social progress, but it can be secured only through the solidarity of the individual with society. An eccentric disposition to look for light only within one's own breast is as irrational as slavish submission to outward authority. What seems to be the inner light of conscience is often only an *ignis fatuus*. A clergyman once asked a man to do his duty. He received the reply "my conscience forbids me to do it." In reply to the clergyman's question, how he knew it, he said "I feel something thumping in my breast, saying 'I wont, I wont' ". This is often the real character of what is supposed to be the dictate of conscience. The Rajah was never unmindful of the rights of man, but he held that the supreme criterion of conduct is the common good and the claims of the individual must always be subordinated to it. Indeed the individual has no good of his own independently of the common good. His views approximated more to those of his German contemporary than to the rationalism of Western Europe.

The religion of Rammohan Roy is not that of the cloister or the hermitage. It is not an affair of Sundays or of the days spent

in pilgrimage. To be religious is not to be peculiar and exceptional, "to stand on one's head or occasionally to paint our faces in order to escape from the weariness of our every day life". Religion is the completion and perfection of life, the dedication of all our energies and activities, mind and will to one that is supreme. Its essence is the transfiguration of the whole of life through the consciousness of our unity with God. The content of it comes entirely from the ordinary interests of life, domestic, social, economic, ethical, political and artistic. It excludes nothing, but transforms everything into the modes of its own expression. Philosophy and science, art and morality, morality and religion must not be regarded as antithetical to each other. The great concerns of human life, although distinct, are complementary to each other and find their unity in that wholeness of life which is the outcome of the knowledge and love of God. Divorced from religion, they degenerate into mere worldliness. If they are to be essential elements of a genuine civilisation, they must be sanctified by being made integral parts of the life of spirit. On the other hand religion becomes an empty thing if it is separated from the world, from ordinary human interests. As Wallace puts it, "you think religion will cure the wretched homes of horried poverty and insolent wealth; but it will not, for religion cannot live where there are such abominations. You fancy morality sits high and safe on the eternal rocks of reason; but probably, if you got nearer, you would find that the venerable queen of life has long since been petrified in those altitudes". The material must be taken up into the spiritual and the spiritual must be bodied forth in the material; the sustaining principle of the world must be religion and religion must find its expression in the life of the world. In this land of ours where flight from the world has always been regarded as the essence of religion, Rajah Rammohan Roy was the first in modern times to preach this message of a healthy-minded religion. It cannot be said that the country has yet sufficiently appreciated the spirit of his teaching. But if we are to make progress along right lines, we cannot afford to remain oblivious of it.

বাঙ্গালী জাতির আত্মপ্রতিষ্ঠা

ভারতীয় ঐক্যের সুফল-কুফল

আজ যুবক বাংলা দুনিয়ার ভিতর অন্যতম বিপুল শক্তি। দেশ-বিদেশের নরনারী যুবক বাংলাকে একটা বিশেষরূপেই উল্লেখযোগ্য শক্তি সমঝিয়া থাকে। বাঙ্গালীর স্বদেশসেবা আর স্বার্থত্যাগ আজকালকার জগতে অন্যতম আধ্যাত্মিক ক্ষমতা হিসাবে সম্মানিত হইতেছে। ১৯০৫ সনের ভাবরাশি বাঙ্গালীজাতিকে সাতাশ আটাশ বৎসরের কাজের ফলে জগতের জাতি-মজলিশে অনেক দূর ঠেলিয়া তুলিয়াছে। বর্ত্তমান সময়ে এই কথা মনে রাখিয়া বাঙ্গালীজাতিকে আগামী তিন, পাঁচ বা সাত বৎসরের জন্য কর্ম্মপ্রণালী বাছিয়া লইতে হইবে। বাঙ্গালীজাতি বিশ্বের রাষ্ট্রমণ্ডলে একটা মজবুত ও কর্ম্মঠ রাষ্ট্র গড়িয়া তুলিতে পারে একথা প্রত্যেক বাঙ্গালীর মাথায় গভীরভাবে বসা আবশ্যক।

ঘটনাচক্রে বাঙ্গালীজাতি নিজেকে অন্যান্য ভারতীয় জাতির সঙ্গে নেহাৎ অচ্ছেদ্য সম্বন্ধে গ্রথিত বিবেচনা করিতে অভ্যস্ত। বাঙ্গালীরা প্রায় আধা শতাব্দী ধরিয়া ভারতবর্ষ, ভারতীয় ঐক্য, ভারতীয় সত্তা, ঐক্যগ্রথিত ভারত, ভারতীয় যুক্তরাষ্ট্র ইত্যাদি শব্দ প্রচার করিয়া আসিতেছে। এই প্রচারের ফলে ভারতবর্ষের বিভিন্ন প্রদেশের মধ্যে কোনো কোনো বিষয়ে খানিকটা একতা আর একপ্রাণতা আসিয়াছে, তাহা সন্দেহ করিবার কারণ নাই। ভারতীয় ঐক্যবিষয়ক চিন্তা আজকাল একমাত্র বাংলাদেশে নয়, বাংলাদেশের বাহিরে অন্যান্য ভারতীয় নরনারীর অন্তরে অন্তরেও যার-পর-নাই বদ্ধমূল। এইরূপ চিন্তার সার্থকতা কিছু না কিছু আছেই, তাহা অস্বীকার করিতেছি না। কিন্তু তাহার একটা কুফলও খুব বড়। এই কুফলের দৌরাত্ম্যে আমরা অনেক বিষয়ে দুর্ব্বল হইয়া পড়িতেছি। ভারতীয় ঐক্যের কথা ভাবিতে ভাবিতে একমাত্র বাঙ্গালী নয়, অবাঙ্গালী ভারতীয়েরাও অনেক বিষয়ে দুর্ব্বল হইয়া

পড়িতেছে। ফলতঃ, ভারতীয় ঐক্যের প্রচার করা আর নানা কর্ম্মক্ষেত্রে দুর্ব্বলতা ডাকিয়া আনা প্রায় একার্থক হইয়া পড়িয়াছে।

যখনই আমরা ভারতের গৌরব, ভারতের কৃতিত্ব, ভারতের কীর্ত্তি প্রচার করি তখনই নিজ পরিচিত পল্লী, শহর বা জনপদ ইত্যাদি ভুলিয়া গিয়া ভারতবর্ষের কোনো-না-কোন পল্লী, কোনো-না-কোনো শহর, কোনো-না-কোনো জনপদের উল্লেখ করিয়া সন্তুষ্ট থাকি। কঙ্কণ-প্রদেশে কোনো একজন ভারতীয় নারী একটা কিছু উঁচুদরের কাজ করিলে, তৎক্ষণাৎ আমরাও বাংলা দেশে ভারতীয় গৌরবের একটা নয়া পরিচয় পাইয়া শ্লাঘা বোধ করি। কখনও বা পাঞ্জাবের কোনো চাষীর কীর্ত্তি, কখনও বা মাদ্রাজের কোনো ধর্ম্মপ্রচারকের কাহিনী, কখনও বা মারাঠাদের জনসেবা-সংক্রান্ত প্রতিষ্ঠান—এই সকল অতি দূরদেশবর্ত্তী নরনারীর কার্য্যাবলী আমাদিগকে পাইয়া বসে। আর আমরাও তাহাতেই ফুলিয়া উঠিতে লজ্জা বোধ করি না। ইহা যে একমাত্র বাংলার দোষ তাহা নহে। মারাঠারাও কখনও কোনো উঁচুদরের বাঙ্গালীর কাজ অথবা মাদ্রাজের চিন্তা লইয়া বেশ খানিকটা গুল্‌তান করিয়া আনন্দ বোধ করে। এই ধরণের পরের উপর নির্ভর করা, পরের মুখে ঝাল খাওয়া, পরের কৃতিত্বকে নিজের কৃতিত্ব সমঝিয়া রাখা ভারতবর্ষের প্রদেশে-প্রদেশে নরনারীর চরিত্রগত হইয়া পড়িতেছে। এই ধরণের পরমুখাপেক্ষিতা অথবা পরের উপর নির্ভরশীলতা কোনো মতেই বাঞ্ছনীয় নহে।

ভারতবর্ষের পঁয়ত্রিশ কোটী লোক—সকলেই আমরা ভারতবাসী এ কথাটা জানিয়া রাখা বা বুঝিয়া রাখা যুক্তিযুক্ত বটে, আর তাহাতে লাভের সম্ভাবনাও আছে। কিন্তু তাহা বলিয়া পদে পদে পাঁচ কোটী বাঙ্গালীর পক্ষে অন্যান্য ত্রিশ কোটী ভারতীয় নরনারীর শক্তি, স্বাস্থ্য, সাহস ও কর্ম্মনিষ্ঠার উপর ধর্ণা দিয়া পড়িয়া থাকা কোনো মতেই যুক্তিযুক্ত নয়। আর তাহাতে লোকসান ছাড়া লাভের সম্ভাবনাও নাই। বাঙ্গালীদের মত মারাঠাদের ঠিক এইরূপ চিন্তা করা উচিত, পাঞ্জাবীদেরও ঠিক এইরূপ চিন্তা করা উচিত, মাদ্রাজীদেরও এইরূপই চিন্তা করা উচিত। ভারতের প্রত্যেক প্রদেশেই চাই আজ স্বতন্ত্র স্বতন্ত্র শক্তিসাধনা ও কর্ম্মসাধনা, স্বতন্ত্র স্বতন্ত্র সাহসিকতা ও কর্ম্মনিষ্ঠার দিগ্বিজয়।

এই শক্তিযোগ আর কর্ম্মনিষ্ঠা বাড়াইয়া তুলিতে হইলে আধ কোটী, এক কোটী, দেড় কোটী, আড়াই কোটী, তিন কোটী, পাঁচ কোটী লোককেই স্বতন্ত্র

স্বতন্ত্র ভাবে—অন্যান্য ভারতীয় নরনারীর কর্ম্মদক্ষতার উপর নির্ভর না করিয়া নিজ নিজ গণ্ডীর ভিতর নানাবিধ কৃতিত্ব দেখাইতে হইবে।

ঐক্য-দর্শনের সেকাল ও একাল

আজ আমি আমার নিজের দেশের কথা বলিতেছি। বাঙ্গালীজাতির ভবিষ্যৎ—সমীপবর্ত্তী ভবিষ্যৎই—আমার একমাত্র আলোচ্য বিষয়। ভারতবর্ষের অন্যান্য প্রদেশের লোকেরা কি করিতেছে বা না করিতেছে সে সম্বন্ধে আলোচনাও বর্জ্জনীয় নয়। কিন্তু তাহারা কিছু করুক বা না করুক, বাঙ্গালী জাতিকে স্বাধীনভাবে নিজের কাজ করিয়া যাইতে হইবে, নিজের জীবন খুলিয়া ধরিতে হইবে। এশিয়া মহাদেশের ভিতর বাঙ্গালীজাতিকে একটা সম্পূর্ণ স্বতন্ত্র ও স্বাধীন সত্তারূপে জীবনধারণ করিতে হইবে। ভারতবর্ষের ভিন্ন ভিন্ন জাতিকে এই ধরণের দশ বিশটা ভিন্ন ভিন্ন স্বাধীন এককে পরিণত করিয়া তোলা অথবা তাহাদের জন্য এই ধরণের স্বাধীন একক হইবার উপযুক্ত চিন্তাপ্রণালী গড়িয়া তোলা যুবক ভারতের পক্ষে একটা সর্ব্বোচ্চ স্বদেশসেবা ও সমাজদর্শন বিবেচনা করিতেছি। বলা বাহুল্য বাঙ্গালীজাতি একমাত্র ভারতের ভিতরই যে স্বাধীন সত্তারূপে বিরাজ করিবে তাহা নহে, সঙ্গে সঙ্গে গোটা দুনিয়ায়ও বাঙ্গালীজাতি একটা স্বতন্ত্র সত্তারূপে ঠাঁই পাইবে। জগতের রাষ্ট্রশক্তির ভিতর বাঙ্গালীজাতি গড়িয়া তুলিবে একটা সম্পূর্ণ স্বতন্ত্র রাষ্ট্র। জগতের আর্থিক শক্তিপুঞ্জের ভিতর আর্থিক বাংলা স্বতন্ত্র এককরূপে তাহার ব্যক্তিত্ব প্রকটিত করিবে। ঠিক এই ধরণেই স্বতন্ত্র আর্থিক একক ও রাষ্ট্রিক এককরূপে ভারতের অন্যান্য জাতিও নিজ নিজ জীবন গড়িয়া তুলুক, কম-সে-কম তাহাদের চিন্তাপ্রণালী এইরূপ স্ব-স্ব প্রধান জীবনবিকাশের অনুরূপ হইতে থাকুক।

কথাটা ঢাক ঢাক গুড় গুড় না করিয়া বলিয়া ফেলিতেছি। ইণ্ডিয়ান ন্যাশন্যাল কংগ্রেস যেদিন হইতে ভারতে প্রতিষ্ঠিত হইয়াছে সেদিন হইতে ভারত, আর ভারতীয় ঐক্য নামক একটা বোল, ভারতবর্ষের নানা স্থানে—প্রায় সকল স্থানেই প্রচারিত হইয়াছে। কিন্তু এই ভারতীয় ঐক্য বিষয়ক ধারণাকে বর্ত্তমান ভারতের নানা কর্ম্মক্ষেত্রে উন্নতির পক্ষে বিশেষ কণ্টকস্বরূপ দেখিতেছি। এই কথা আমি পনর বিশ বৎসর ধরিয়াই ভিন্ন ভিন্ন উপলক্ষ্যে প্রচার করিয়া আসিতেছি। চীন দেশে থাকিবার সময় (১৯১৫) চীনের অবস্থা আলোচনা করিতে

করিতে এই তথাকথিত ভারতীয় ঐক্যের বিশ্লেষণও বিশেষভাবে করিয়াছিলাম। একটা বিশাল মহাদেশ, যেখানে পঁয়ত্রিশ কোটী নরনারী বাস করে, সেই ধরণের মহাদেশকে একটা ঐক্যগ্রথিত নরনারীর রাষ্ট্র বিবেচনা করা ইয়োরেশিয়ার মধ্যযুগে সুপ্রচলিত ছিল। তখনকার দিনে ইয়োরোপের বাদশারা গোটা ইয়োরোপকে অথবা আধখানা ইয়োরোপকে অথবা শিকিখানা ইয়োরোপকে নিজ নিজ তাঁবে আনিয়া ঐক্যগ্রথিত ইয়োরোপের উপর একাধিপত্য চালাইতেন অথবা চালাইতে চেষ্টা করিতেন। তখনকার দিনে চিন্তাবীর, কবি, দার্শনিক ইত্যাদি লোকেরাও এইরূপ ঐক্যগ্রথিত ইয়োরোপ সম্বন্ধে আদর্শ প্রচার করিতেন। আমাদের ভারতীয় বাদশারা অনেকেই রাজচক্রবর্ত্তী, সার্ব্বভৌম অথবা এই ধরণের কিছু হইতে চেষ্টা করিতেন। তাহা ছাড়া ধর্ম্মশাস্ত্র, নীতিশাস্ত্র, অর্থশাস্ত্র ইত্যাদি রাজশাস্ত্রের প্রচারকেরাও এইরূপ সর্ব্বগ্রাসী বিশাল ঐক্য-বিশিষ্ট সাম্রাজ্য কল্পনা করিতে প্রবৃত্ত হইতেন। কিন্তু সে সব কি ইয়োরোপে কি এশিয়ায় পাগ্‌লামি ছাড়া আর কিছুই ছিল না। মধ্যযুগে তথাকথিত ইয়োরোপীয় ঐক্য আর তথাকথিত ভারতীয় ঐক্য কথার কথা মাত্র ছিল। তাহাতে হয়ত বা সামাজিক লেন-দেনে, ধর্ম্মের আচার প্রচারে, বিশেষতঃ বড় ঘরের কৌলীন্যপ্রথায় একটা ঐক্য বা সাম্য অতি দূর-দূর দেশের ভিতরও প্রতিষ্ঠিত হইয়াছিল। কিন্তু রাষ্ট্রীয় ঐক্য, নরনারীর রাষ্ট্রগত একতা ইত্যাদি বলিলে বর্ত্তমান যুগে যে ধরণের জনগণ-নিয়ন্ত্রিত স্বরাজের কথা উঠে, সে সব চীজ মধ্যযুগের ইয়োরোপে অথবা ভারতীয় বাদশাতন্ত্রে দেখা যাইত না। সেই সব ঐক্য ছিল রাষ্ট্রীয় গোলামীর আর রাষ্ট্রীয় যথেচ্ছাচারের নামান্তর মাত্র। যাহা হউক, উনবিংশ শতাব্দীতে ইয়োরোপে এই সেকেলে ঐক্যের মায়ামৃগ আর কাহাকেও প্রলুব্ধ করিতে পারে নাই।

নেপোলিয়নের পরবর্ত্তী যুগে ইয়োরোপীয়ানরা বুঝিয়া লইয়াছে যে, ইয়োরোপের ভিন্ন ভিন্ন প্রদেশে এই ঐক্য কায়েম করা সম্ভবপর নহে। কাজেই তাহারা খোলাখুলি ইয়োরোপকে টুকরা টুকরা করিয়া ভিন্ন ভিন্ন স্ব-স্ব প্রধান স্বাধীন রাষ্ট্রশক্তিতে বাঁটিয়া লইয়াছে। এই ভাগ-বাটোয়ারার কাজ যে সম্পূর্ণ হইয়াছে, সে কথা এখনও বলা চলে না। এখনও বহুদিন ধরিয়া ভার্সাই সন্ধির পরেও স্বতন্ত্র একক গড়িয়া তুলিবার অবস্থা ইয়োরোপে থাকিবে। কিন্তু ভারতবর্ষে আমরা আহাম্মুকের মত সেই মধ্যযুগের বুলি আর মধ্যযুগের কাজটা একালেও বেমালুম চালাইয়া যাইতেছি। তথাকথিত

ভারতীয় ঐক্যের পেছনে না ছুটিয়া অথবা আজকালকার তথাকথিত ফেডারেশ্যনের খপ্পড়ে না পড়িয়া ভারতবাসীর উচিত ছিল সোজাসুজি ভারতবর্ষকে ভিন্ন ভিন্ন স্ব-স্ব প্রধান স্বাধীন শক্তিকেন্দ্রে টুকরা টুকরা করা। ভারতে বিচক্ষণ রাষ্ট্র-সমজদার থাকিলে তাঁহারা ভারতকে ঐকেগ্রথিত করিবার কথা না ভাবিয়া তাহাকে ছোট ছোট শক্তিশালী কতকগুলো স্বাধীন দেশে পরিণত করিবার ফিকির ঢুঁড়িতে চেষ্টা করিতেন।

ইয়োরোপের মতন অনৈক্য চাই ভারতে

ভারতবর্ষ গোটা ইয়োরোপের প্রায় দুই-পঞ্চমাংশ। গোটা ইয়োরোপ বলিতে ইয়োরোপীয়ান রুশিয়াও অন্তর্গত করিতেছি। অথবা যদি ইয়োরোপীয়ান রুশিয়াকে বাদ দিই, তাহা হইলে ইয়োরোপের যতটুকু থাকে তার প্রায় বার আনা হইল আমাদের ভারত। ভারতীয় নরনারীকে যেখানে-সেখানে যখন-তখন একটা ঐক্যগ্রথিত অথবা ফেডারেলী-কৃত ভারতীয় রাষ্ট্র গড়িয়া তোলা সম্বন্ধে বক্তৃতা করিলে ঠিক তেমনি আহাম্মুকির পরিচয় দেওয়া হয় না কি,—যেমন ইয়োরোপের তিন-চতুর্থাংশের নরনারীকে একটা ঐক্যগ্রথিত ইয়োরোপীয় রাষ্ট্র বা রাষ্ট্র-সংঘ বা সংযুক্ত-ইয়োরোপ গড়িয়া তোলার জন্য প্রাণপাত করিতে বলিলে হয়? দুইটাই আমার চিন্তায় সমান বুদ্ধিহীনতার পরিচয়। যে সব লোক ভারতবাসীকে এরূপ তথাকথিত ঐক্যগ্রথিত ভারত গড়িয়া তুলিবার পরামর্শ দিয়া আসিতেছে, তাহারা ভারতের বন্ধু নহে। তাহারা আমাদের স্বদেশসেবকগণকে এমন একটা পথের কথা বলিয়াছে যে পথে যুগ-যুগান্তর ধরিয়া চলিলেও কোনদিন শেষ সীমায় আসিয়া পৌঁছান যাইবে না। ইয়োরোপীয়ানরা যে পথে চলিয়াছে সে পথে তাহারা একটা চলনসই স্বাধীনতা অর্জ্জন করিয়াছে। তাহাতে ইয়োরোপের মোটের উপর লাভই হইয়াছে। ছোট ছোট জনপদে এই ধরণের রাষ্ট্রীয় স্বাধীনতা এবং আত্মকর্ত্তৃত্ব লাভই ভারতবাসীর পক্ষেও বাঞ্ছনীয় ছিল। কিন্তু যে পথে চলিলে এই ধরণের সাফল্যলাভ হইতে পারিত সেই পথ মাড়াইতে না দেওয়াই যেন ভারতীয় ঐক্য সম্বন্ধে পরামর্শদাতাদের মতলব ছিল। ভারতীয় ঐক্যের প্রচারকেরা যদি বিদেশী হন, তাহা হইলে যে তাঁহারা আমাদের শত্রু সে বিষয়ে সন্দেহ নাই। যদি তাঁহারা ভারতসন্তান হন, তাহা হইলে তাঁহারা অবুঝ—এই কথাই আমি বলিতে যাইতেছি। পঁয়ত্রিশ কোটী ভারতীয় নরনারীকে এমন একটা কাজ করিতে বলা হইতেছে যাহা

ইয়োরোপের ঠিক ততগুলি লোক সমাধা করিতে পারে নাই। আসল কথা, ফরাসীবিপ্লবের পর হইতে তাহারা ইয়োরোপের ভিতর যে যে কাজ, যে ধরণের কাজ প্রাণপণে এড়াইয়া আসিয়াছে—যে ধরণের কাজ তাহারা কোন মতেই যুক্তিসঙ্গত বিবেচনা করে নাই, ঠিক সেই ধরণের কাজ—একটা অসম্ভব, অসাধ্য, যুক্তিহীন কাজ—ভারতসন্তানকে ঘাড়ে লইবার জন্য অহরহঃ বক্তৃতা করা হইতেছে।

আমরা ভারতবাসীরা অনেক দিন ধরিয়া রাষ্ট্র-জীবনের যথার্থ বস্তু সম্বন্ধে অন্ধতা পরিপোষণ করিয়া আসিয়াছি। কতকগুলি শব্দের পেছনে ছুটিয়া তাহার গুণগান করিতে করিতে আমরা আমাদের আসল কর্ত্তব্য ভুলিয়া গিয়াছি। এখন হইতে আমাদিগকে চোখ খুলিয়া নিজের চোখে দুনিয়া দেখিয়া, কি সম্ভব কি অসম্ভব তাহা সম্বন্ধে গোঁজামিল না রাখিয়া, সোজা পথে কাজে নামিতে হইবে।

আয়তন ও লোকবল

আজকালকার বোম্বাই প্রদেশ আয়তনে ইয়োরোপের ইতালি অথবা নরওয়ের সমান। আসাম প্রদেশ গ্রীসের চেয়ে কিছু বড়, চেকোশ্লোভাকিয়ার চেয়ে কিছু ছোট। মাদ্রাজ আর পোল্যাণ্ড আয়তনে প্রায় সমান সমান। আর আমাদের বাংলাদেশ চেকোশ্লোভাকিয়া ও লিথুয়ানিয়া এই দুইটী ইয়োরোপীয়ান রাষ্ট্রের সমান। মজার কথা,—একালের ইয়োরোপে যাঁহারা কর্ম্মিৎকর্ম্মা রাষ্ট্র-ধুরন্ধর অথবা রাষ্ট্র-দার্শনিক তাঁহারা ইউনিটি বা ঐক্যের স্বপ্ন দেখেন না অথবা একটা ফেডারাল-কাঠাম কল্পনা করেন না। ইয়োরোপকে তাঁহারা বহুসংখ্যক ইয়োরোপে বিভক্ত দেখিতে চাহেন, আর করিয়াছেনও তাহাই।

ইয়োরোপে আজকাল ত্রিশ বত্রিশটী ভিন্ন ভিন্ন স্বাধীন দেশ বিরাজ করিতেছে। তাহাদের কেহ বড়, কেহ মাঝারী, কেহ ছোট। ইয়োরোপের মত গঠনমূলক রাষ্ট্রকৌশল যদি আমাদের থাকিত তাহা হইলে আমাদের ভারতীয় মহাদেশে কম-সে-কম দুই ডজন স্ব-স্ব প্রধান স্বাধীন জাতি বা রাষ্ট্র দেখিতে পাইতাম। ভারতবর্ষের আয়তন লক্ষ্য করিয়াই এই সংখ্যা উল্লেখ করিলাম। ইয়োরেপে যদি গোটা ত্রিশেক স্ব-স্ব প্রধান স্বাধীন দেশ থাকিতে পারে, আর তাহাতে যদি একটা তথাকথিত আন্তর্জ্জাতিক হযবরল, গণ্ডগোল বা অরাজকতা বিরাজ করিতেছে এইরূপ না বলা যায়,—তাহা হইলে ভারতবর্ষে

গোটা চব্বিশেক স্বাধীন রাজ্য চলিতেছে এইরূপ দেখিলে দুনিয়ার কোনো লোক তাহাকে একটা অরাজকতা, গণ্ডগোল বা হযবরল বলিতে অধিকারী হইবে কেন ? ইয়োরোপকে লোকেরা যে মাপে মাপিতেছে, ভারতকেও সেই মাপেই মাপা উচিত।

আচ্ছা, এইবার আয়তনের কথা ভুলিয়া গিয়া লোকসংখ্যার কথা ধরা যাউক। প্রশ্ন এই,—কতগুলি লোক থাকিলে এক একটা স্বাধীন রাষ্ট্র গড়িয়া উঠিতে পারে ? এই সম্বন্ধে কোনো নিয়ম আছে কি ? নাই। ইয়োরোপের দৃষ্টান্তে আবার আমরা ভারতের সম্বন্ধে কর্ত্তব্য বিশ্লেষণ করিতে পারিব। বুলগারিয়ায় প্রায় পঁচাত্তর লক্ষ লোক। অর্থাৎ এক কোটীরও কম লোক লইয়া বুলগারিয়ার নরনারী একটা স্বাধীন রাষ্ট্র গড়িয়াছে। তাহা হইলে ভারতের আসামী বেচারারা কি দোষ করিল ? বস্তুতঃ এই ধরণের অল্প সংখ্যক লোক লইয়া আসামেও একটা স্বতন্ত্র রাজ্য কেন গড়িয়া উঠিবে না ? এই মাপে বিচার করিলে বুঝিতে পারি যে, স্পেনের সমানদরের একটা রাজ্য গড়িয়া তুলিতে পারে আমাদের পাঞ্জাবীরা। আর গ্রেটবৃটেনের সমানসংখ্যক লোক লইয়া মাদ্রাজীরা একটা স্বাধীন রাষ্ট্র গড়িয়া তুলিতে অধিকারী। যুক্তপ্রদেশ আর বাংলাদেশ এই দুই মুল্লুকেই প্রায় পাঁচ কোটী লোক, গ্রেট বৃটেনের কিছু বেশী আর জার্ম্মাণির কিছু কম। কাজেই যুক্তপ্রদেশের নরনারী আর বাঙ্গালীজাতি বেশ দুইটী বড় বড় রাষ্ট্র গড়িয়া তুলিতে অধিকারী। ইয়োরোপীয়ান রুশিয়া বাদ দিলে ইয়োরোপের যতটুকু বাকি থাকে, তাহার লোক-সংখ্যা আমাদের গোটা ভারতের লোকসংখ্যার সমান। কাজেই ইয়োরোপের দেখাদেখি ভারতেও আমাদের লোকেরা যদি গোটা ত্রিশ বত্রিশ স্ব-স্ব প্রধান রাষ্ট্র গড়িয়া তোলে, তাহা হইলে মহাভারত অশুদ্ধ হইতে পারে না ; রাষ্ট্রনৈতিক তর্কশাস্ত্রে অথবা রাষ্ট্রনৈতিক কর্ত্তব্যজ্ঞানে ভারতবাসীকে ইয়োরোপীয়ানদের চেয়ে নিম্নপদস্থ বিবেচনা করা চলিতে পারে না। করিতে গেলে "গা-জুরি" দেখানো হইবে মাত্র। ইয়োরোপ-সুলভ অনৈক্যই চাই আজ ভারতে। ইয়োরোপীয়ান পণ্ডিত আর রাষ্ট্রিকেরা এই কথা বলিবেন না। কিন্তু এই কথা বলাই যুবকভারতের সর্ব্বশ্রেষ্ঠ স্বদেশসেবকগণের পক্ষে একমাত্র কর্ত্তব্য। নয়া বাংলার গোড়া পত্তনের কাজে সর্ব্বপ্রথম জরুরি কাজ এই নবীন বস্তুনিষ্ঠ রাষ্ট্রদর্শন। যুবক বাংলার স্বদেশসেবা, স্বার্থত্যাগ ও উন্নতিনিষ্ঠা এই নবীন দর্শনের কর্ম্মকাণ্ডে মূর্ত্তিমন্ত হইয়া উঠুক।

নেশ্যন-রাষ্ট্রের আসল কথা

ইয়োরোপের অনৈক্যের মতই অনৈক্য চাই ভারতে। বস্তুতঃ এই ভারতীয় অনৈক্য দেখিয়া ভারতবাসীর লজ্জিত হওয়ার কোনো কারণ নাই।

এবার আর একটা কথা বলিব—আরও গভীর। ইয়োরোপের এই যে ত্রিশ বত্রিশটা ছোট ছোট স্বাধীন দেশ, তাদের প্রত্যেকটার ভিতরে কোনো প্রকার ঐক্য আছে কি? অনেক ক্ষেত্রেই বিলকুল না। অথচ আমরা ভারতে আহাম্মুকের মতন বুলি আওড়াইয়া থাকি যে, ইয়োরোপের ভিন্ন ভিন্ন দেশগুলি বাস্তবিক এক একটা ঐক্যগ্রথিত দেশ। ইংরেজীতে একটা শব্দ ব্যবহৃত হয়। সেটা ঐক্যগ্রথিত অথবা একতাশীল লোকসমষ্টির প্রতিশব্দ বিশেষ। তাহাকে বলে "নেশ্যন"। আমাদের রাষ্ট্রিক মহলে, সাংবাদিক মহলে, দার্শনিক মহলে, সাহিত্যিক মহলে, পণ্ডিত মহলে, সর্ব্বত্রই একটা ধারণা জন্মিয়া গিয়াছে যে, ইয়োরোপের ছোট ছোট স্বাধীন দেশগুলি বাস্তবিকই এক একটা "নেশ্যন" অর্থাৎ জীবনের সকল প্রকার কর্ম্মক্ষেত্রে পুরোপুরি ঐক্যবিশিষ্ট সমষ্টি। আসল কথা অনেক ক্ষেত্রেই প্রায় এক দম উল্টা। ইয়োরোপের "নৃতত্ত্বে" হাতেখড়ি হইবামাত্র "চিচিং ফাঁক" হইয়া যাইবে। ইয়োরোপ সম্বন্ধে ইয়োরোপীয়ানরা আমাদিগকে যাহা কিছু শিখাইয়াছে অথবা ইয়োরোপ সম্বন্ধে আমরা যাহা কিছু বুঝিয়া রাখিয়াছি কিংবা বলিয়া থাকি, তাহার প্রায় সবই আগাগোড়া ভুল। বিশেষ আশ্চর্য্যের কথা এই যে,—ইয়োরোপের প্রত্যেক প্রদেশের ভিতরকার অসংখ্য অনৈক্য সম্বন্ধে আজ পর্য্যন্ত ভারতীয় পণ্ডিত বা রাষ্ট্রিক মহলে আসল তথ্যপূর্ণ জ্ঞান জন্মিল না। এক একটা তথাকথিত ইয়োরোপীয়ান নেশ্যন-রাষ্ট্র বিশ্লেষণ করিয়া দেখা যাউক। কি দেখিতে পাই? প্রায় প্রত্যেকটার ভিতরেই দেখিতে পাই একাধিক ভাষার প্রভাব অথবা আধিপত্য। আবার প্রত্যেকটীতে দেখিতে পাই একাধিক "জাতির" প্রভাব অথবা আধিপত্য। "জাতি" অনুসারে রাষ্ট্র ইয়োরোপের প্রায় কোথাও নাই। ভাষাহিসাবে রাষ্ট্রও এক প্রকার ইয়োরোপের কোথাও নাই। প্রায় প্রত্যেক রাষ্ট্রেই বহু ভাষার জয়জয়কার। আবার প্রত্যেক রাষ্ট্রে বহু জাতিরও জয়জয়কার। ইহাই হইল ইয়োরোপের রাষ্ট্রবিধানের গোড়ার কথা।

রক্ত ও ভাষা

ধরা যাউক ফ্রান্স। ফ্রান্স এমন একটা দেশ যেখানে অনেক বিষয়ে

কতকগুলি ঐক্য আছে। ফ্রান্সকে অনেক বিষয়ে আমরা ঐক্যবিশিষ্ট লোক-সমষ্টির সুবিস্তৃত জনপদ বলিয়া বিবেচনা করিতে পারি। করিলে বেশি ভুল হইবে না। কিন্তু তবু বাস্তবিক পক্ষে, ফ্রান্সের "জাতিগত" ঐক্য বা সামঞ্জস্য নাই বলা উচিত। আছে "জাতিগত" বৈচিত্র্য। এখানকার লোক-সংখ্যা ৪০,৭৫০,০০০। এই কিঞ্চিদূর্দ্ধ চার কোটী নরনারীর ভিতর ১,৭০০,০০০ জার্ম্মাণ, ১,০০০,০০০ কেল্ট, ৬০০,০০০ ইতালিয়ান, ২৫০,০০০ স্পেনিস। তাহা ছাড়া অন্যান্য কুচাকাচা প্রায় ৬০০,০০০। অধিকন্তু ফ্রান্সের যাহারা আসল "ফরাসী" তাহাদের ভিতরও অসংখ্য "জাতি", "উপজাতি" রহিয়াছে।

এইবার একটা ছোট দেশের কথা ধরা যাউক—নাম বেলজিয়াম। এখানে চল্লিশ লক্ষ ফ্লেমিশ নরনারীর সঙ্গে ঘর করে ত্রিশ লক্ষ বিশ হাজার হ্বালুন জাতীয় নরনারী। তাহার উপর আছে লাখ খানেক জার্ম্মাণ, অধিকন্তু লাখ চারেক অন্যান্য জাতীয় লোকও বেলজিয়ামে বাস করে। অর্থাৎ ফ্লেমিশ জাতীয় লোক এখানে অর্দ্ধেকের সামান্য কিছু বেশি।

একটা প্রশ্ন নৃতত্ত্বের সঙ্গে সঙ্গে রাষ্ট্রতত্ত্বেও আসিয়া পড়ে। সেটা এই—"জাতি" ("রেস") কাহাকে বলে? জাতি শব্দে কি রক্তের কথা বুঝিতে হইবে? তাহা হইলে রাষ্ট্র-বিজ্ঞানের ক্ষেত্রে এত ভজকট আসিয়া পড়ে যে, তাহার কূলকিনারা পাওয়া যায় না। কেন না পৃথিবীর প্রত্যেক জনপদের প্রত্যেক বিঘাতেই রক্ত-সংমিশ্রণ অর্থাৎ দো-আঁসলা জাতির অস্তিত্ব দেখিতে পাই। কাজেই তথাকথিত খাঁটী স্বদেশী রক্ত নামক বস্তু পৃথিবীর কোথাও চক্ষু-গোচর হয় না। সুতরাং অমিশ্র রক্তওয়ালা নরনারীর দলকে এক একটা স্বাধীন রাষ্ট্রের কেন্দ্র অথবা উপাদান বিবেচনা করিতে হইলে পৃথিবীর কোথাও "নেশ্যন" বা ঐ ধরণের একটা রাষ্ট্র বা দেশ গড়িয়া তোলা সম্ভবপর নয়। জগতের সর্ব্বত্রই বিরাজ করিতেছে মিশ্র বা দো-আঁসলা জাতি। পৃথিবীর সর্ব্বত্রই দো-আঁসলা "জাতি" লইয়াই রাষ্ট্র গড়িয়া উঠিতে বাধ্য। "জাতি" শব্দটা তাহা হইলে অনেক সময় ছাড়িয়া দেওয়াই বোধ হয় বুদ্ধিমানের কাজ। তাহার বদলে হয়ত বা ভাষা শব্দটা ব্যবহার করিলেও চলিবে। অথবা জাতি "রেস" শব্দটাকে ভাষার প্রতিশব্দ স্বরূপ ব্যবহার করিলেও অনেক সময় কাজ চলিয়া যাইতে পারে। এখন দেখা যাউক—ভাষা হিসাবেও "নেশ্যন"-রাষ্ট্র ইয়োরোপে আছে কি না। থাকিলে কয়টা আছে? ফ্রান্স এবং বেলজিয়াম

দুই দেশের নাম করিয়াছি। এই দুইটাই বনিয়াদি দেশ—অর্থাৎ মহা লড়াইএর পূর্ব্বেও ইহাদের অস্তিত্ব ছিল; এই দেশ দুইটা নামজাদাও বটে। দেখিলাম—জাতিহিসাবে অর্থাৎ প্রকারান্তরে ভাষাহিসাবেও এই দেশ দুইটা বাস্তবিক ঐক্যগ্রথিত নেশ্যন-রাষ্ট্র নয়।

পোল্যাণ্ড ও চেকোস্লোভাকিয়া

এইবার কতকগুলি নয়া রাষ্ট্রের কথা বলিব। এই সব রাষ্ট্র লড়াইএর পর ইয়োরোপে কায়েম হইয়াছে। লড়াইএর পূর্ব্বে এই সব দেশের নাম কেহ জানিত না। বিচিত্র কথা—লড়াইএর খতম হইয়াছে যে সব সন্ধিতে, সেই সকল সন্ধিতে এই অর্ব্বাচীন দেশগুলিকে তথাকথিত "নেশ্যন"-রাষ্ট্র নামে খুব লম্বা গলায় প্রচার করা হইয়াছে। এইরূপ তথাকথিত "নেশ্যন"-দেশের ভিতর একটা আজকাল বেশ সুপরিচিত। তার নাম পোল্যাণ্ড। এইবার তাহা হইলে পোল্যাণ্ডের ভিতর একটু পায়চারী করিয়া আসা যাউক। দেখি এখানকার নরনারীরা তাদের হাড়মাসে কোন্ কোন্ জাতির পরিচয় দেয়। শহর পল্লীর লোকজনের সঙ্গে একটু আধটু গা-ঘেঁষাঘেঁষি করিলেই দেখিতে পাওয়া যাইবে যে, এই তথাকথিত নেশ্যন-দেশের ভিতর খাঁটী পোলিশ হাড়মাসের লোক শতকরা ৫২·৭; অর্থাৎ প্রায় আধাআধি লোকই এই দেশের "খাঁটী স্বদেশী" নয়। এদেশের লোকসংখ্যা ২৭,০০০,০০০। ইহার ভিতর শতকরা একুশজন লোক উক্রেন রক্তের লোক, শতকরা এগারজন ইহুদীর বাচ্চা, শতকরা ৭·৩ শ্বেতরুশ, শতকরা সাতজন জার্ম্মাণ। তাহা ছাড়া অন্যান্য গোৎকারাকা জাতি শতকরা একজন ধরিতে হইবে।

এইবার আর একটা নয়া রাষ্ট্রের কথা বলিব। সে চেকোস্লোভাকিয়া। এই দেশটার নামের সঙ্গেই দুইটা জাতি বা রক্ত বা হাড়মাস গাঁথা আছে। বুঝিতে হইবে যে, কম-সে-কম দুইটা ভাষা এই তথাকথিত "নেশ্যন"-রাষ্ট্রের গোড়া দখল করিয়া বসিয়া আছে। আসল কথা, যত রকম রক্ত, ততগুলা ভাষা। এইবার দেখা যাউক, এই দেশের ভিতর শহরে পল্লীতে কোন্ কোন্ রংএর, কোন্ কোন্ রূপের লোকেরা বাস করে। একটা জাতির নাম চেক। ইহারা হইতেছে শতকরা ৪৪'৪। যে জাতির নাম দেশটার দ্বিতীয় অংশে পাই, সে জাতির অর্থাৎ স্লোভাক রক্তের লোক এই মুল্লুকে শতকরা মাত্র ১৪·৮। ইহাই হইল তথাকথিত নেশ্যন-রাষ্ট্রের কারচুপি। অবশিষ্ট

লোকগুলি কাহারা? তাহাদের ভিতর লোকসংখ্যার শতকরা ২৭'৪ হইল জার্ম্মাণ, শতকরা ছয়জন ম্যাজিয়ার।

বুঝা যাইতেছে সোজা কথা, এই যে নবীনতম রাষ্ট্র যাহার ভিতর নাকি নেশ্যন-ধর্ম্ম প্রচুর পরিমাণে বর্ত্তমান, তাহাতে মাইনরিটি অর্থাৎ সংখ্যালঘিষ্ঠ নরনারীর সমষ্টি বেশ পুরু। আর মধ্যযুগে ও প্রাচীনকালে ত এই ধরণের সংখ্যালঘিষ্ট দলের অস্তিত্ব খুব বেশীই ছিল। বুঝিতে হইবে যে, কি সেকালে কি একালে একাধিক জাতি এবং একাধিক ভাষা প্রায় প্রত্যেক রাষ্ট্রেরই বনিয়াদ রহিয়াছে। এ সম্বন্ধে গোঁজামিল রাখিয়া চলা আহাম্মুকির চূড়ান্ত ছাড়া আর কিছুই নয়। দুর্ভাগ্যের কথা, ভারতে আমরা এই গোঁজামিল আর এই আহাম্মুকি অনেক দিন ধরিয়া চালাইতেছি। যুবক বাংলার রাষ্ট্র-বীরদের এখন উচিত তাহাদের মগজ হইতে এই আহাম্মুকিটা ঝাড়িয়া ফেলা। শেয়ানার মত শেয়ানার সঙ্গে কোলাকুলি করিতে অভ্যস্ত হওয়া আজ তাহাদের পক্ষে বিশেষ জরুরী। ইয়োরোপীয়ান পণ্ডিতদের প্রচারিত বুজরুকিগুলি শুনিবামাত্র হতভম্ব হইয়া যাওয়া তাহাদের পক্ষে বাঞ্ছনীয় নয়। জোরের সহিত, সাহসের সহিত, পাকা খেলোয়াড়ের মতন ইয়োরোপের দেশগুলি সম্বন্ধে মতামত প্রচার করিবার জন্য প্রস্তুত হওয়া ভারতীয় রাষ্ট্রকর্ম্মীদের পক্ষে নেহাৎ আবশ্যক। বিশেতঃ আজ তাহাদিগকে ভারতবর্ষের মানচিত্র লইয়া বিশেষভাবে মাথা খাটাইতে হইবে। এইজন্য ইয়োরোপের মানচিত্রটা নখদর্পণে রাখিয়া কাজে প্রবৃত্ত হওয়া দরকার। ইয়োরোপের মানচিত্রটা ইয়োরোপের রাষ্ট্রিকেরা যে ধরণে টানিয়াছে, ভারতের কর্ম্মবীরেরাও ভারতবর্ষের ম্যাপকে সেই ধরণে টানিতে পারিলেই ওস্তাদির পরিচয় দেওয়া হইবে।

সোজাসুজি বুঝিয়া রাখা আবশ্যক যে, তথাকথিত জাতিগত ঐক্য অনুসারে পৃথিবীর কোনো মুল্লুকে রাষ্ট্র কায়েম করা অসম্ভব। জাতিগত ঐক্যের সূত্র অনুসারে হওয়া উচিত—যেখানে যেখানে নয়া নয়া ভাষা সেখানে সেখানে নয়া নয়া রাষ্ট্র। অথবা যেখানে যেখানে নয়া নয়া হাড়মাস বা রক্ত সেখানে সেখানে নয়া নয়া রাষ্ট্র। এই দুই সূত্র কার্য্যে পরিণত করা সম্ভব। এ কথাটা ভারতবাসীকে নিরেটভাবে—বস্তুনিষ্ঠভাবে ইয়োরোপের দৃষ্টান্ত দেখিয়া বুঝিয়া লইতে হইবে। কাজেই বাংলাদেশে বাঙ্গালীজাতি যে রাষ্ট্র গড়িয়া তুলিবে সেই রাষ্ট্রে কতকগুলি অ-বাঙ্গালী জাতি ও অ-বাংলা ভাষা থাকিবেই থাকিবে। ইহা প্রথম হইতেই বুঝিয়া লওয়া দরকার। চেকোস্লোভাকিয়ার

মত, পোল্যাণ্ডের মত, বেলজিয়ামের মত বা ফ্রান্সের মত বাংলাদেশেও একটা রাষ্ট্র কায়েম করিতে হইলে অ-বাঙ্গালীর অস্তিত্ব হঠানো সম্ভব হইবে না। অ-বাঙ্গালী জাতির হাড়মাস এবং অ-বাঙ্গালীর ভাষা নিজের কর্ম্মক্ষেত্রের ভিতর পুষিয়াও বাংলার নরনারীর পক্ষে একটা রাষ্ট্র গড়িয়া তোলা সম্ভব। এইরূপ একাধিক ভাষা ও একাধিক জাতি লইয়া ঘর করিতে থাকিলে বাঙ্গালীজাতিকে বিশেষরূপে নিন্দনীয় অথবা দুর্ব্বল বিবেচনা করা চলিবে না। সংসারে অন্যান্য দেশ, জাতি বা রাষ্ট্রগুলিকে যে মাপকাঠিতে বিচার করা হইয়া থাকে, বাঙ্গালী জাতিকে তাহা হইতে পৃথক্ অথবা তাহার চেয়ে বড় বা কঠিন কোনো মাপ-কাঠিতে বিচার করিতে যাওয়া বেকুবি অথবা 'বজ্জাতি' ছাড়া আর কিছু নয়।

খ্রীষ্টান সমাজে ধর্ম্মের লড়াই

এইবার তাহা হইলে ধর্ম্মের কথা কিছু বলি। যুবক বাংলার রাষ্ট্রবীরগণ বস্তুনিষ্ঠভাবে কর্ম্মক্ষেত্রে প্রবেশ করিলেই দেখিতে পাইবেন যে, রাষ্ট্রগঠনে ধর্ম্মের ঠাঁই সম্বন্ধে তাঁহারা অনেক কিছু বুজরুকি শিখিয়াছেন। ইয়োরোপের নৃতত্ত্বে ধর্ম্মের দঙ্গল, ইয়োরোপীয় রাষ্ট্রে ধর্ম্মের প্রভাব, ইয়োরোপের নরনারীর ভিতর ধর্ম্মভেদ ইত্যাদি বস্তু তলাইয়া মজাইয়া বুঝিয়া দেখা দরকার। ইয়োরোপে এমন কোনো তথাকথিত "জাতি"-রাষ্ট্র আছে কি যেখানে আমরা বলিতে পারি যে, বাস্তবিক তাহাতে রাষ্ট্রের সীমানা আর ধর্ম্মের সীমানা এক, অর্থাৎ এমন কোনো রাষ্ট্র ইয়োরোপে আছে কি যেখানে একাধিক ধর্ম্মের অস্তিত্ব বা প্রভাব নাই? আমাদের দেশে সাধারণতঃ আমরা বিবেচনা করি যে ইয়োরোপের দেশগুলিতে ধর্ম্মসম্বন্ধে ভেদাভেদ বা গোলযোগ কিছু দেখা যায় না। সেখানকার রাষ্ট্রগুলিকে সবই একধর্ম্মাবলম্বী নরনারীর দেশ বিবেচনা করা আমাদের দস্তুর। আসল অবস্থা ঠিক তার উলটা। আবার আমাদিগকে শিখানো হইয়া থাকে যে, আমাদের দেশে যতদিন একাধিক ধর্ম্মের অস্তিত্ব বা প্রভাব থাকিবে, ততদিন আমাদের দেশে রাষ্ট্র বা জাতি-রাষ্ট্র বা স্বাধীনতা ইত্যাদি কিছুই আসিতে পারে না। এই মত বর্ত্তমান যুগের সমাজ-দর্শনে একটা প্রকাণ্ড মিথ্যা। এত বড় বুজরুকি আমরা পঞ্চাশ ষাট সত্তর বৎসর ধরিয়া বেমালুম হজম করিয়া যাইতেছি,—ইহাতে লজ্জায় মাথা হেঁট করিয়া থাকিতে হয়। আসল কথা কি? আমরা যাহা শিখিয়াছি, আমাদিগকে

যাহা শিখানো হইয়াছে, আসল বস্তুনিষ্ঠ রাষ্ট্রবিজ্ঞান ঠিক তাহার উল্টা। ধরা যাউক হাঙ্গারি দেশ, এটা একটা নয়া রাষ্ট্র। লড়াইএর পূর্ব্বে ইহার অস্তিত্ব ছিল না। এই দেশে কয়টা ধর্ম্ম? খ্রীষ্টান রোমানক্যাথলিক শাখা এখানকার লোকসংখ্যার শতকরা ৬৩ জন নরনারীর জীবন নিয়ন্ত্রিত করে। খ্রীষ্টানদের প্রটেস্টান্ট শাখা নিয়ন্ত্রিত করে শতকরা ২১.৩ জন লোককে। এভাঞ্জেলিষ্ট নামক আর এক শাখা নিয়ন্ত্রিত করে শতকরা ৬.২ জন নরনারীকে। "অর্থডক্স" (গোঁড়া) গ্রীক শাখা নামক খ্রীষ্টান ধর্ম্মের এক বড় সম্প্রদায় হাঙ্গারি দেশের শতকরা ২.১ জন লোকের ধর্ম্মনিয়ন্তা। তাহা ছাড়া আছে ইহুদী। ইহুদীরা অখ্রীষ্টান, তাহাদের আওতায় বসবাস করে শতকরা ৬.২ জন নরনারী। বাকী থাকে শতকরা একজন, তাহাদিগকে অন্যান্য ধর্ম্মের যজমানরূপে গণ্য করা যাইতে পারে। কি দেখিলাম?—দেখিলাম ঘোর ধর্ম্ম-বৈচিত্র্য।

ভারতে আমাদের অনেকের বিশ্বাস যে, ইয়োরোপীয়ান দেশে ধর্ম্মসংক্রান্ত গোলযোগ কিছু নাই। ইহাও ভুল। প্রথমেই জানিয়া রাখা উচিত যে, খ্রীষ্টান ধর্ম্মের আইনে ক্যাথলিক শাখার পুরুষ বা নারী প্রটেষ্টাণ্ট শাখার নারী বা পুরুষকে বিবাহ করিতে পারে না। যে দুই সম্প্রদায়ে বিবাহ হয়, বলা বাহুল্য সেই দুই সম্প্রদায়ে পারিবারিক মেলামেশা আর সামাজিক লেনদেন অনেক বিষয় সঙ্কুচিত থাকিতে বাধ্য। অর্থাৎ সঙ্গে সঙ্গে বুঝিতে হইবে যে, পরসম্প্রদায়-বিশেষ, পরধর্ম্মের বিরুদ্ধে মতামত, নিন্দা-প্রচার ইত্যাদি লাগিয়াই আছে। ইয়োরোপের যে কোনো দেশে, শহরে অথবা বিশেষভাবে পল্লীতে যে সকল ভারতবাসী বসবাস করিয়াছে এবং কিছু ঘনিষ্ঠভাবে বিভিন্ন পরিবারের সংশ্রবে আসিয়াছে, তাহারাই জানে যে ক্যাথলিক পরিবারের সঙ্গে প্রটেষ্টাণ্ট পরিবারের সামাজিক অসহযোগ একটা প্রথম স্বীকার্য্য। ঝগড়াঝাটি কত আছে, কত খুঁটিনাটি লইয়া এই দুই সম্প্রদায়ে মনোমালিন্য উপস্থিত হয়, আর তাহার প্রভাব পার্লামেন্টে, নগরশাসনে, সামাজিক বৈঠকে, সাহিত্যসমালোচনায়, সংবাদপত্রে ও বিশ্ববিদ্যালয়ে কত রকম বাদবিসম্বাদ হাজির করে, নেহাৎ হাঁড়ির খবর যাঁহারা না জানেন তাঁহারা তাহা বুঝিতে পারিবেন না। তাহা সত্ত্বেও ওসব দেশের দৈনিক, সাপ্তাহিক, মাসিক পত্রে ক্যাথলিক-বিরোধী অথবা প্রটেষ্টাণ্ট-বিরোধী দল, আন্দোলন এবং মতামত যে-সে লোকের নজরে পড়ে। তাহার উপর আসিয়া জোটে ইহুদী-সমস্যা। একে প্রটেষ্টাণ্ট-ক্যাথলিক দ্বন্দ্ব, তাহার উপর দুইয়েরই—বিশেষতঃ ক্যাথলিকদের ইহুদী-বিদ্বেষ। বুঝিতে হইবে ইয়োরোপের

প্রত্যেক দেশে—সে যত ছোটই হউক—একটা ধর্ম্মগত ত্র্যহস্পর্শ লাগিয়াই আছে। বলা বাহুল্য মামুলি ধর্ম্মের বিধানে ইহুদীর সঙ্গে ক্যাথলিকের বিবাহ নিষিদ্ধ। তাহা ছাড়া, খাওয়া-দাওয়া আর অন্যান্য সামাজিক উঠা-বসায় এক জাতি আর এক জাতির মুখ দেখে না। ইহুদী পরিবারে খ্রীষ্টানদের নিমন্ত্রণ কোনো দিন আমার চোখে পড়ে নাই। আবার খ্রীষ্টান গৃহস্থের ঘরেও আমি বহুসংখ্যক অতিথির ভিতর একজনও ইহুদী দেখি নাই। একটা কথা বলিয়া রাখা উচিত যে, ইহুদীরা জ্ঞানে বিজ্ঞানে খুব বড়। চিত্রকর, গায়ক, উকীল, ডাক্তার, বৈজ্ঞানিক, সাহিত্যিক, সমালোচক, সাংবাদিক আর ব্যাঙ্কার এই কয় মূর্ত্তিতে ইহুদীরা ইয়োরোপের প্রত্যেক দেশেই শীর্ষস্থানীয়দের মধ্যে পরিগণিত। তাহা সত্ত্বেও সামাজিক লেন-দেনে ইয়োরামেরিকা জাতি-বিদ্বেষ ধ্বংস করিতে পারে নাই। এক হিসাবে ইহুদীদের জল ইয়োরোপের সাধারণ খ্রীষ্টানসমাজে এক প্রকার "অচল" বলিলেই ভারতবাসী তাহাদের সামাজিক অবস্থা বুঝিতে পারিবে। বহুসংখ্যক ইয়োরামেরিকান প্রটেষ্টাণ্ট, ক্যাথলিক ও ইহুদী পরিবারের ভিতরকার কথা আমার নিত্যনৈমিত্তিক জীবনের অন্তর্গত। কাজেই অনেক কিছু দেখিবার ও শুনিবার সুযোগ জুটিয়াছে। ধর্ম্মবিদ্বেষ ঐ সকল দেশের একটা মস্ত বড় কথা। আর তার প্রভাব রাষ্ট্রনৈতিক জীবনেও খুব বেশী। অতএব বুঝা গেল যে, ধর্ম্মগত ভেদ, ধর্ম্মবিদ্বেষ, ধর্ম্ম-কলহ ইত্যাদি থাকা সত্ত্বেও ইয়োরোপের ছোট ছোট দেশগুলি এক একটা স্বাধীন রাষ্ট্র গড়িয়া তুলিয়াছে। অর্থাৎ ধর্ম্মের ঐক্য স্বাধীনতার ভিত্তি নয়। ধর্ম্মের অনৈক্য থাকা সত্ত্বেও পৃথিবীতে মানুষ স্বাধীন জাতি, দেশ বা রাষ্ট্র গড়িয়া তুলিতে সমর্থ। আর, তাহাই ইতিহাসের চোখে স্বাভাবিক কথা। এই সকল ধর্ম্মগত অনৈক্য আছে বলিয়া হাঙ্গারিকে আধুনিক ইয়োরামেরিকার রাষ্ট্রবীরেরা স্বাধীনতা সম্বন্ধে অযোগ্য বিবেচনা করে কি? এই সকল অনৈক্য থাকা সত্ত্বেও হাঙ্গারির নরনারীকে একটা স্বাধীন রাষ্ট্র গড়িয়া তুলিবার অধিকার দেওয়া হয় নাই কি? মনে রাখা আবশ্যক যে, হাঙ্গারি মাত্র আশী লক্ষ নরনারীর বাসভূমি; অর্থাৎ এই সামান্য সংখ্যক লোক যেখানে বাস করে, সেরূপ ছোট দেশেও ধর্ম্মের অনৈক্য, গণ্ডগোল ও ঝগড়াকোঁদল প্রচুর পরিমাণেই বিদ্যমান, আর তাহা সত্ত্বেও সেই সব নরনারীকে স্বাধীন রাষ্ট্রের নরনারী বলিয়া বিবেচনা করা হইতেছে।

যথার্থ রাষ্ট্র-বিজ্ঞান

এই সকল কথা বুঝিতে পারিলে যুবক ভারতের গঠন-মূলক ভবিষ্যপন্থী কর্ম্মবীরেরা ধর্ম্মগত ঐক্যের মোহ কাটাইয়া উঠিতে পারিবে। আর তাহা হইলে দুনিয়ার ছোট, বড়, মাঝারি দেশে যে প্রণালীতে ও যে পথে রাষ্ট্র গড়িয়া তোলা হইয়াছে, সেই প্রণালীতে এবং সেই পথে ভারতবর্ষেরও বিভিন্ন প্রদেশে বিভিন্ন স্ব-স্ব প্রধান ছোট, বড়, মাঝারি রাষ্ট্র গড়িয়া তুলিবার দিকে ভারতবাসীর মতিগতি খেলিতে থাকিবে। আর তাহা হইলেই সুরু হইবে ভারতে যথার্থ রাষ্ট্রবিজ্ঞানের অ, আ, ক, খ।

শ্রীবিনয়কুমার সরকার

সহজ মানুষকে নমস্কার

শিক্ষক হিসেবে গুরুশিষ্যের সম্পর্ক নিয়ে শ্রদ্ধেয় শ্রীযুক্ত ডাক্তার প্রফুল্লচন্দ্র দেশের ছাত্রদের মনে কত বড় স্থান অধিকার করে আছেন, তা কারো অবিদিত নাই। দু'একটি অনুষ্ঠানে গিয়ে দেখেছি কি গভীর স্নেহ, শ্রদ্ধা ও প্রীতির আদান-প্রদান চলেছে রায়মহাশয় এবং তাঁর শিষ্যমণ্ডলীতে। মনে তখনি খেদ জেগেছে হায় এই মানুষটিকে ঐ গুরুশিষ্যের মধুর সম্বন্ধ নিয়ে বোঝা আমার অদৃষ্টে ঘটলো না। আমরা কয়েকজন আছি যারা যুবা স্যার প্রফুল্ল রায়কে দেখেছি, আজও দেখছি সেই মানুষটিকে; বুড়ো হয়ে গেছেন কিন্তু সেই আগেকার সদাপ্রফুল্ল পুরুষ। কালের সঙ্গে আমরা বদলাই প্রায় বেশিরভাগ মানুষই; বয়স এসে পরিয়ে দিয়ে যায় নানা সাজ; ইচ্ছায় অনিচ্ছায় নানানতরো মুখস বদলিয়ে চলি সংসার পথে; আড়ালে পড়ে যায় আসল মানুষটি। এই যে ইচ্ছাকৃত এবং কালের কৃত বদল—সাজে গোজে চালে চোলে—ঘরে বাইরে মানুষকে একটা কৃত্রিমতার আবরণে আড়াল করে তফাতে মঞ্চে তুলে রাখে, তেমনটি ঘটা থেকে নিস্তার পায় ক্বচিৎ কোন মানুষ। তারি একজন হলেন আচার্য্য প্রফুল্লচন্দ্র রায় মহাশয়—অত বড় নামজাদা মানুষ, একেবারে কিন্তু সাদাসিধা সহজ মানুষটি। নামের বদনাম স্পর্শই করেনি তাঁকে। তাইতো ছোট ছেলে থেকে ষাট বছরের বুড়োর কাছে তিনি অবারিতদ্বার হয়ে বসে আছেন। সেদিন বাগান-অঞ্চলে যেতে 'বেঙ্গল কেমিক্যালের' কারখানা চোখে পড়লো এক বিস্ময়কর বিরাট শক্তির প্রতিমূর্ত্তি। এই কারখানার স্রষ্টাকে দেখি—ভয়ও দেন্‌না কাছে যেতে, বিস্ময়ও জাগান্‌ না গাম্ভীর্য্যের মস্ত আড়ম্বর নিয়ে। এই রকম সহজ মানুষকে দেখেই কবিরা বলে গেলেন—"নিরঞ্জন সৃষ্টি নর অমূল্য রতন, ত্রিভুবনে কেহ নাহি নরের মতন—তারাগণ শোভা দিল আকাশমণ্ডল, নরজাতি দিয়া হল পৃথিবী উজ্জ্বল।" নমস্কার! নমস্কার!! নমস্কার!!!

শ্রীঅবনীন্দ্রনাথ ঠাকুর

The Place of Embryology in the Study of Animal Structure

By Himadri Kumar Mookerjee (Calcutta).

(Plate II).

The study of morphology becomes difficult when it comes to determine the exact limitation of a particular structure. This difficulty increases when we want to know the relative value of the structure in a comparative way. In the animal world variation lies in different directions and these variations can only be explained if we know the embryology, habit and ecology of the animals. Thus, in order to determine the exact value of a particular structure, we must know the developmental history of that animal which leads us to the study of embryology.

Each animal passes through a series of successive stages and this we speak of as ontogeny. Some of the ontogenetic stages are universally familiar to us, such as those of the tadpoles of frog or the caterpillars of butterfly.

Nothing is more fascinating to a biologist than the study of organic evolution, and this can only be studied if we study the ontogenetic history, for we know that ontogeny repeats phylogeny, that is, the history of an individual repeats the history of the race.

It was from the famous German embryologist Haeckel that we got the biogenetic law or his theory of recapitulation. Von Bear, before the time of Haeckel, held the idea of progressive deviation. At the present day the theory of recapitulation still has its staunch supporters like Professor MacBride, who says, "the larval phase of development represents a former condition of the adults of the stock to which it belongs."

Smith Woodward, the palaeontologist, says that he is con-

vinced that whenever he is able to trace lineages he finds evidence of the recapitulation of ancestral characters in each life-history.

Adam Sedgwick showed that from earlier stages of development it is possible to distinguish the very closely related animals.

His, the famous embryologist, went further than this when he said that in early stages of development animals can be distinguished into class, order, species and even sex.

During the last seven years I have been working on embryology and I shall now pick up a few illustrations from my own ivestigations to show how the study of embryology is of such great importance, in order to co-ordinate a particular structure with the habit and ecology of the animal concerned.

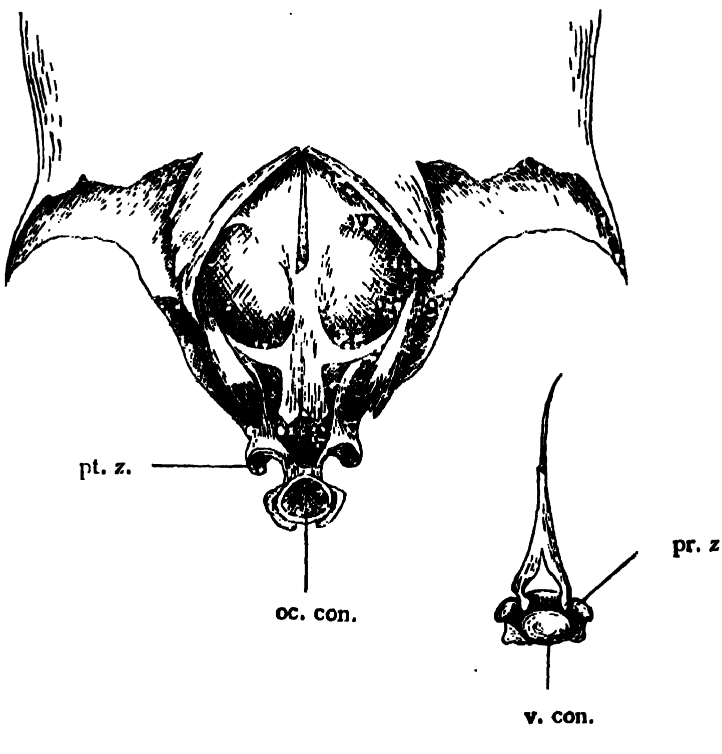

Fig. 1.—Back of the skull and also the first vertebra of *Ophiocephalus striatus* showing the concave occipital condyle and the heavy zygapophyses between the skull and the first vertebra. X 2.

oc. con., occipital condyle; pr. z., prezygapophysis; pt. z., postzygapophysis; v. con., vertebral condyle.

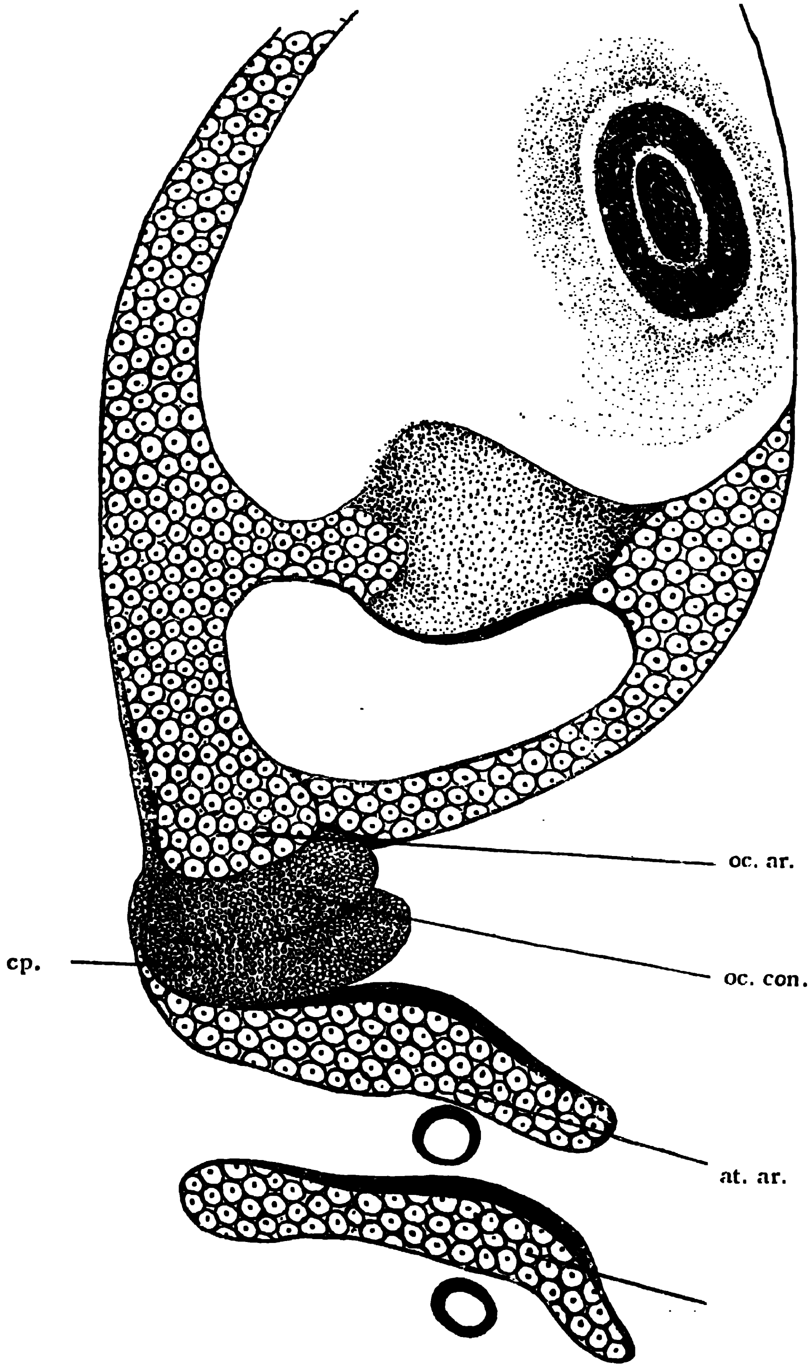

Fig. 2.—Sagittal section through the occipital and the atlas regions of a young *Bufo melostictus* at 12 mm. stage after metamorphosis X 50.

at. ar., atlas arch; ax. ar., axis arch; cp., cup; oc. ar., occipital arch; oc. con., occipital condyle.

The number of occipital condyles, i.e., the point of articulation of the skull to that of the vertebral column varies according to the different classes in the vertebrata. Fishes, reptiles and birds have a single condyle whereas amphibia and mammalia have double condyles. Much depends on the number of occipital condyles because of the fact that one can, from the number, easily distinguish a skull of either fish, reptile or bird, or amphibian or mammal, i.e., such an important single character will determine the class.

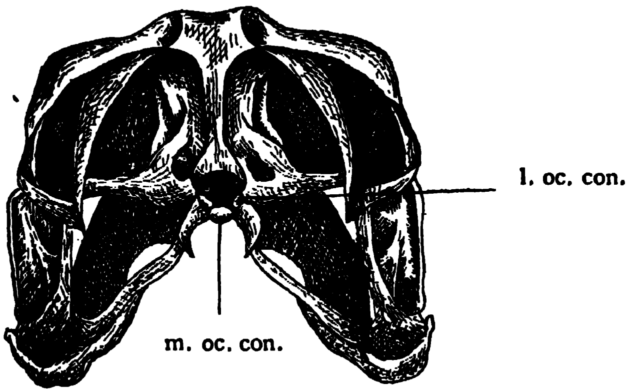

Fig. 3.—Back of the skull of Calotes versecolour showing the occipital condyle X 4. l. oc. con., lateral part of the occipital condyle; m. oc. con., middle part of the occipital condyle.

Now, how to account for this variation? Whether a single occipital condyle of fishes, reptiles and birds is divided into two or the double occipital condyles of amphibians and mammals fuse into one, or they have different modes of origin, is the question. The extreme hinder limit of the skull is the occipital arch. The occipital condyles of the skull of vertebrata are separate elements from the occipital arch, and are ultimately superimposed on the latter, except in fish, although external morphological study shows that their origin is the same. Prior to the investigation of the writer, it was the general idea that occipital arch and occipital condyle were of the same origin.

The occipital arch being the hinder limit of the skull, the arch which is the beginning of the vertebral column may be termed

atlas, though it is not homologous in Anamnia and Amniota for the obvious reason that the first group has 10 pairs of cranial nerves, while the second has 12 pairs. Between the occipital region and the atlas there is an intervertebral body which acts as a buffer. An intercalated arch is present on the dorsolateral sides of this intervertebral body, the existence of which was not previously known; this arch is not complete dorsally and does not enclose the spinal cord, the nerve, spinalis I, passes through or over this intercalated arch.

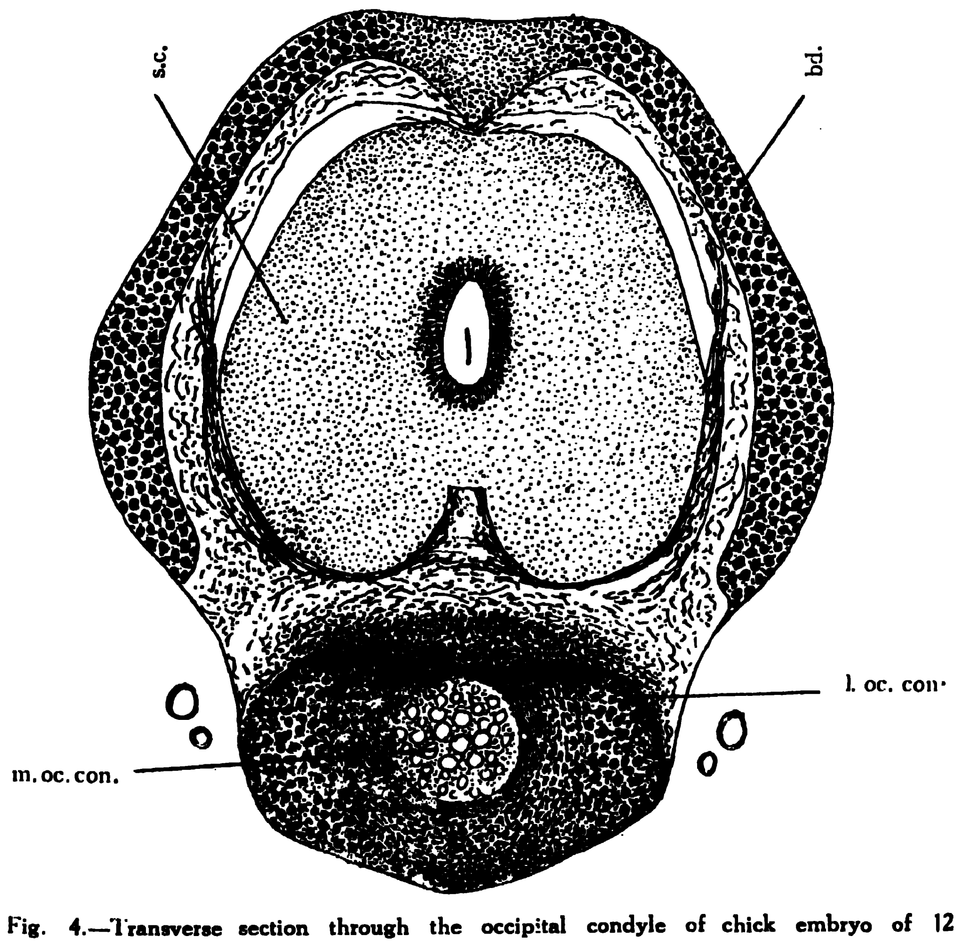

Fig. 4.—Transverse section through the occipital condyle of chick embryo of 12 days showing the constituent parts of the occipital condyle X 60.

bd., basidorsal of the atlas vertebra; l. oc. con., lateral part of the occipital condyle formed from the intercalated arch between the occipital arch and the atlas arch; m. oc. con., middle part of the occipital condyle formed from the perichordal tube of the intervertebral portion; s.c., spinal cord.

In Fish, the limbs of this intercalated arch lie on the sides, a little above the level of the intervertebral body, so that when a strand of migratory connective tissue cells divides each of the limbs into two parts, those look like zygapophyses between the occipital arch proper and the atlas arch proper. These zygapophyses are very massive in comparison with the zygapophyses of the other vertebrae. The anterior portion of the intervertebral body, after the division, fuses with the occipital arch to form the occipital condyle. It is concave, as the vertebrae of fish are amphicoelous (Fig. 1).

In Urodela, the intercalated arch lies almost at the same level as the intervertebral body and when the division of the two limbs of the intercalated arch gives rise to two occipital condyles, the intervertebral body, instead of being divided, fuses with the anterior end of the atlas, thus forming the so-called odontoid process.

In Anura, the condition of the intercalated arch is exactly like that of Urodela. The two limbs of the intercalated arch is divided into two, one part fusing with the occipital arch to form the occipital condyle and the other part fusing with the anterior portion of the atlas vertebra, thus to fit in with the condyle (Fig. 2). In Anura the intervertebral body, unlike that of Urodela, becomes divided. One part fuses with the atlas and the other part fuses with the occipital region, in consequence of which there is no formation of an odontoid process.

In Gymnophiona, the formation of the occipital condyles is just like that of Anura.

In all Amniota, i.e., in reptiles, birds and mammals, the limbs of the intercalated arch lie at the sides, a little below the level of the intervertebral body.

In Reptiles, the anterior part of the intercalated arch, which becomes divided from the posterior part, gives rise to the lateral portion of the single occipital condyle, while the intervertebral body fuses entirely with the skull to form the median portion of the occipital condyle. Thus arises the single elliptical occipital condyle (Fig. 3).

The formation of the single occipital condyle in birds is almost like that of the reptiles, except that the lateral portions of it, instead of having a big massive structure like reptiles, are narrow strips, so that the whole occipital condyle looks almost like a round body (Fig. 4).

In Mammalia the formation of the occipital condyles which are two in number develops exactly like that of Anura.

From the above statement it is clear that the formation of the

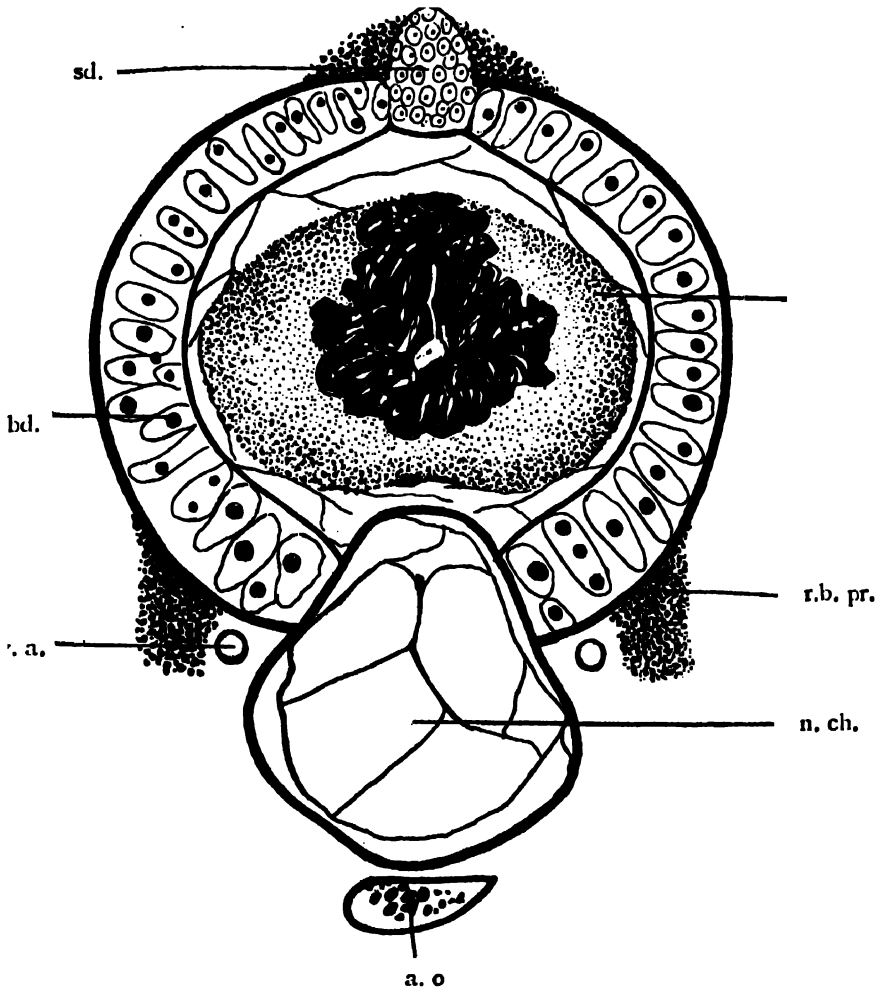

Fig. 5.—Transverse section through the trunk vertebra of *Triton vulgaris* at 20 mm. stage showing the complete cartilaginous neural arch X 100.

ao., aorta; bd., basidorsal; n.c., nerve cord; n.ch., notochord; r. b. pr., rib-bearing process; sd., supradorsal; v.a., vertebral artery.

occipital condyles depends on three structures :—(1) and (2) the two limbs of the intercalated arch that stands between the last occipital arch and the first vertebral arch, and (3) the intervertebral body at this region, except in the case of Fish where the first two factors alluded to are excluded and the single occipital condyle is formed from the intervertebral body only.

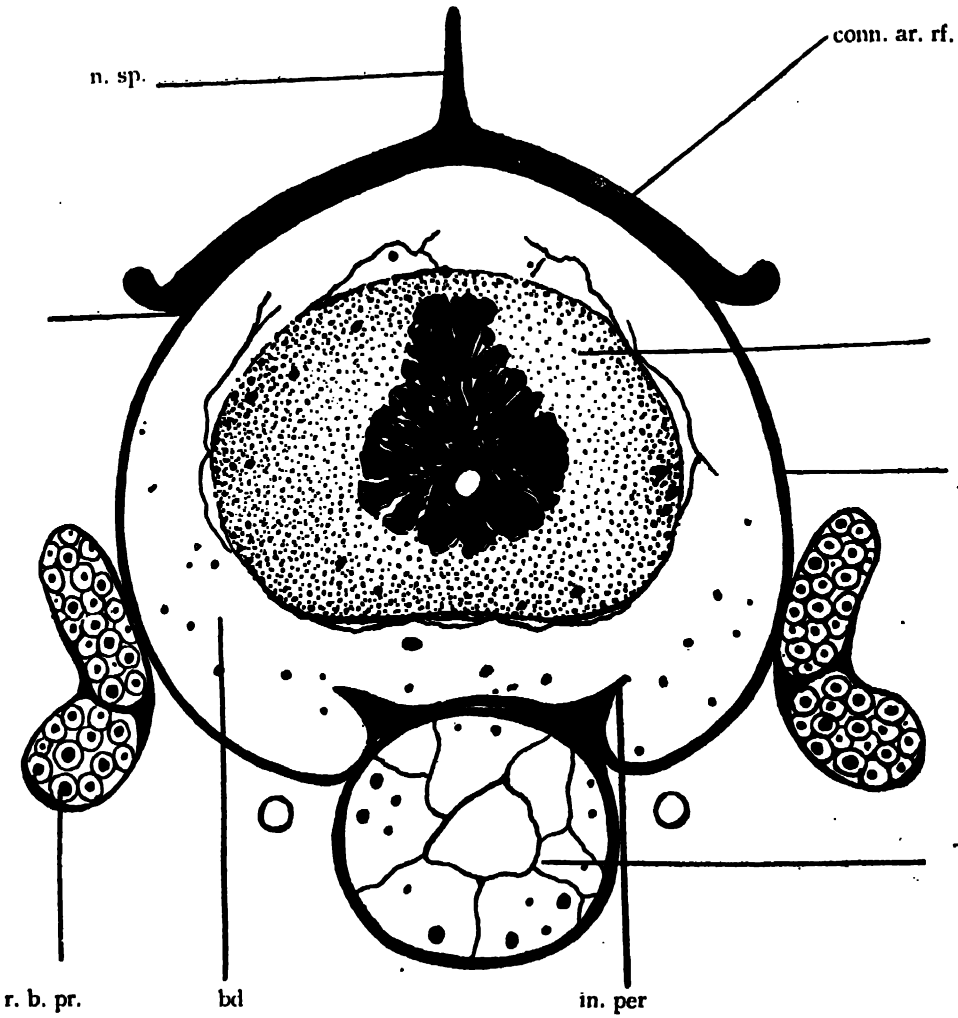

Fig. 6.—Transverse section through a trunk vertebra of *Triton vulgaris* at 20 mm. stage showing the degenerated basidorsals X 80.

bd., basidorsal; conn. ar. rf., connective tissue arch roof; d. shf., dorsal shelf; in. per., inner perichondrium in course of dissolution; cut. per., outer perichondrium of basidorsal which ossifies; r.b. pr., rib-bearing process.

Triton vulgaris is a sluggish animal and contrary to popular idea this newt is not an aquatic animal; it merely enters the water in the spring to breed. As this creature has lungs and not gills in the adult stage, it has to float in the water to take in air from the atmosphere. In order to facilitate such floating, the body should

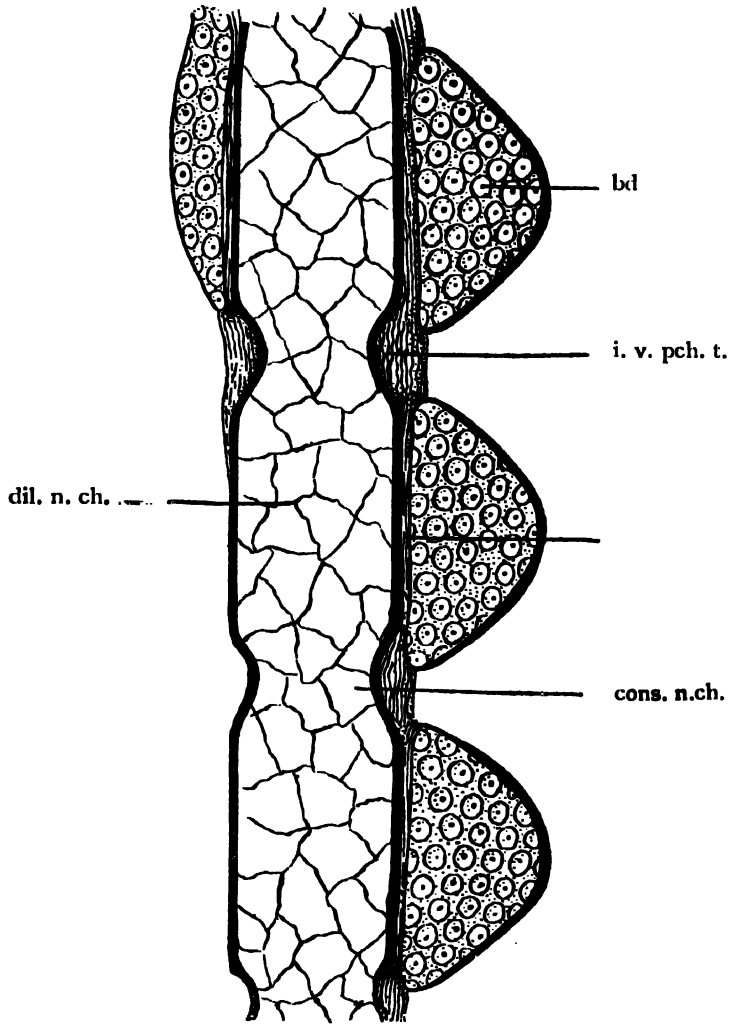

Fig. 7.—Parafrontal section through the trunk vertebrae of the tadpole of *Rana temporaria* at 22 mm. stage showing the perichordal tube outside the notochordal sheath X 100.

bd., basidorsal; c.c.. cartilage cell; cons. n. ch., constriction of the notochord; dil. n. ch., dilatation of the notochord; i.v. pch. t., intervertebral perichordal tube.

be very light. The heaviest tissue of the body of a vertebrate animal is the skeletal system. In the developing stage, the neural arch, that is the one that envelopes the spinal cord, as well as the haemal arch that protects the blood vessels are cartilaginous

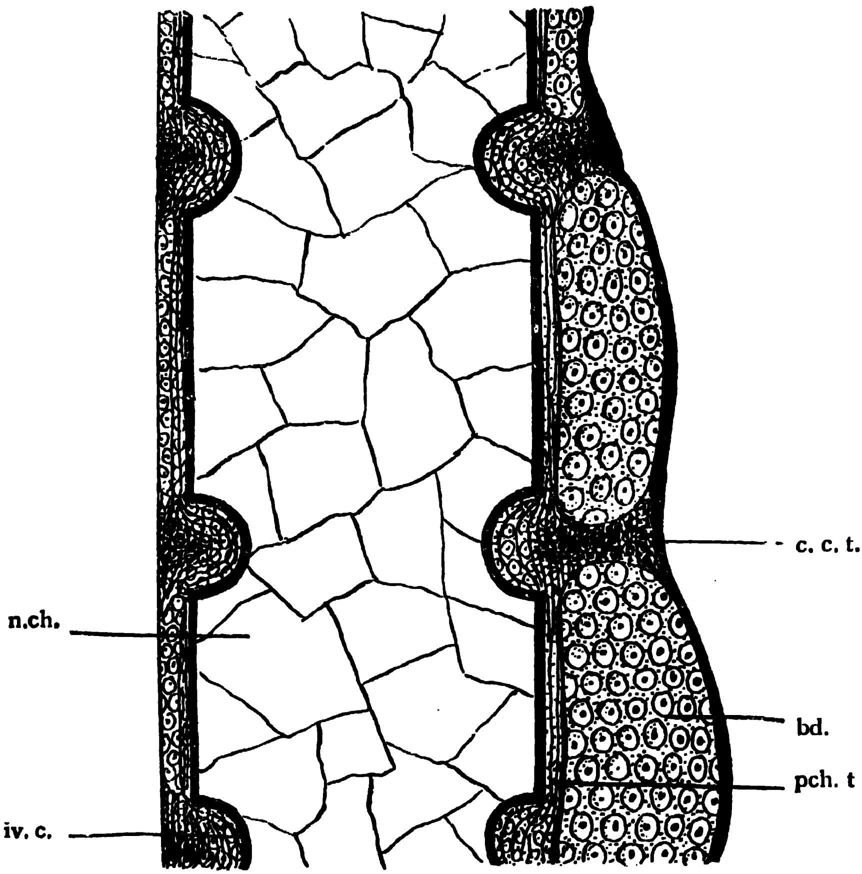

Fig. 8.—Frontal section through the trunk vertebra of young *Rana temporaria* at 12 mm. stage after metamorphosis X 80.

bd., basidorsal; c.c.t., connective tissue growing in to form articulation iv.c., intervertebral cartilage; pch. t., perichordal tube; n. ch., notochord.

arches. At this stage the animal has gills to receive oxygen from water, but as it grows into adult stage these cartilaginous arches undergo modifications. The cartilaginous arches are formed from the two basidorsals on either side with a supradorsal on the top to complete the neural arch, and for the haemal arch the two basiven-

trals on either side with an infraventral at the bottom to complete it (Fig. 5).

The modification of these cartilaginous arches takes place as the animal grows into the adult condition, with their degeneration. The degeneration does not take place in the neural or the haemal arch as a whole, but cartilaginous cells of the basidorsals together with the inner perichondrial layer degenerate, leaving behind the outer perichondrial layer of the basidorsals together with the cartilaginous supradorsal (Fig. 6). Thus ultimately the cartilaginous supradorsal and the outer perichondrial layers of the basidorsals of either side are converted into bone. In the case of the haemal arch the cartilaginous infraventral together with the outer perichondrial layers of the basidorsals of either side are converted into bone. A comparative study of sections of cartilaginous stage with the adult osseous stage shows that the thickness of the cartilaginous arches is greater than in the adult osseous arches, because after the degeneration the latter is represented by the outer perichondrial layer only. It is a sort of puzzle to find that in the larval stage the arches are thicker and in the adult stage these elements look thinner. This form of degeneration of the cartilaginous structure in the newt has not been recorded by any worker before the present author. Thus the massive cartilaginous vertebral column becomes lighter.

The surface area of the animal remains the same but the weight of the body becomes lighter, which enables the creature to float without much effort in the water during the breeding period.

If we take the measurement of a tadpole from the tip of the snout to the end of the cloaca which is the common duct for the urinary, the digestive and the reproductive systems, and also measure the same animal in its young condition of frog after metamorphosis, we find that in the latter, the length will diminish. How are we to account for this puzzling diminution when we know that the skeletal system is a very rigid element Soon after the formation of the notochord, vacuoles appear within the notochordal tissue. The peripheral notochordal cells form a definite layer,

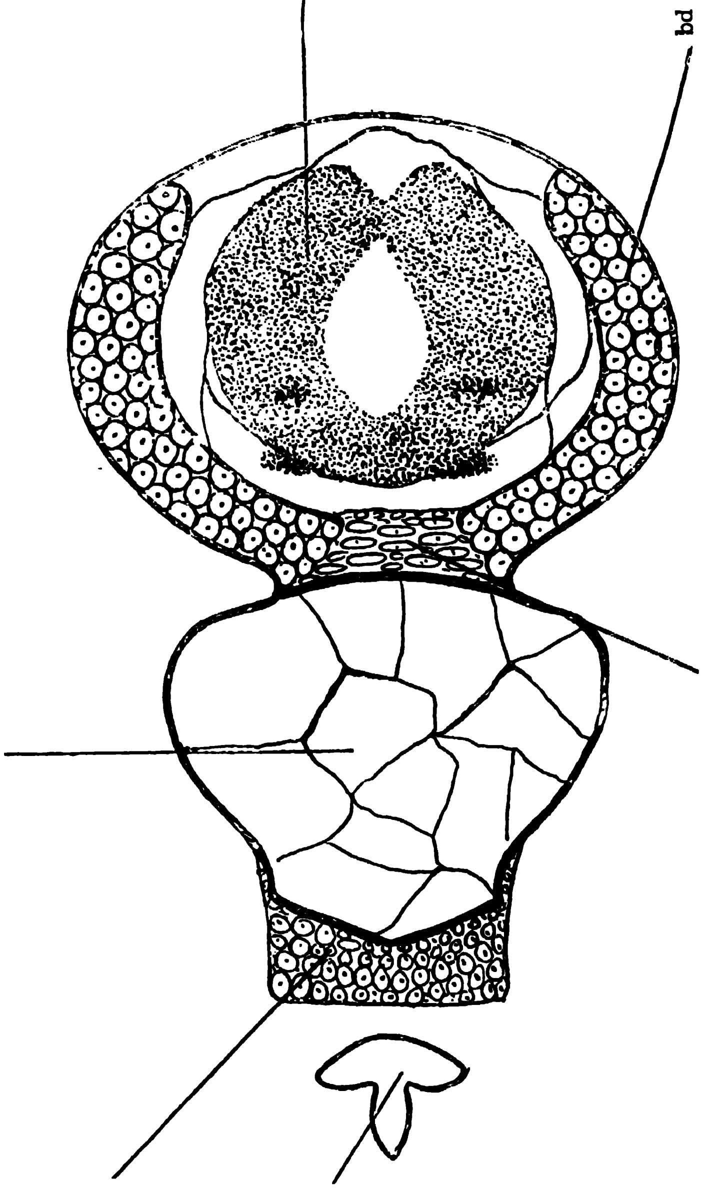

Fig. 9.—Transverse section of a trunk vertebra of *Xenopus laevis* at 52 mm. stage before complete metamorphosis X 80.

ao., aorta; bd., basidorsal; d. pch. t., dorsal perichordal tube; n.c., nerve cord; n. ch., notochord; m.v. pch. t., midventral portion of the perichordal tube which is cartilaginous.

which is called the notochordal epithelium. The notohordal epithelium in its turn is covered externally by two thin membranes, the elastica externa and the elastica interna, which are the products of the secretion of the notochordal cells. In the meantime the mesodermal somites have liberated the sclerotomic cells from the ventro-median corners. The remnants of the mesodermal somites are now called the myotomes. The sclerotomic cells which are liberated from the mesodermal somites change their shape and become fibrous. These fibrous cells surround the notochord by aggregating in the centre of the myotomal regions forming rings—the perichordal rings. The rings of the fibrous connective tissue have extended in a cranial as well as in a caudal direction so as to form a continuous tube—the perichordal tube. Corresponding to each myotome there is a spinal nerve ganglion opposite the cranial half, and opposite the caudal half a scattered aggregation of sclerotomic cells. The notochord which had a uniform diameter now exhibits moniliform swellings. There are dilatations opposite the middle of each myotome and constrictions opposite the intermyotomal regions. This moniliform shape of the notochord is, of course, caused by the perichordal tube outside it.

The dorsolateral aggregations of sclerotomic cells exert pressure and constrict the notochord and the perichordal tube in the intermyotomal (vertebral) regions. The part of the perichordal tube at the bases of the dorsolateral aggregations is so thin that they seem to rest directly on the notochordal sheath.

The fibrous perichordal tube in the intervertebral region is thickened, and owing to the pressure exerted by the dorsolateral aggregations (basidorsals) on it—before and behind it—forms an outward bulge in the middle of the intervertebral region with two tapering ends and thus the zone of growth of the perichordal tube is restricted to the intervertebral portions. The bulging constricts the notochord a little, so that the place where originally the notochord was dilated now becomes constricted (Fig. 7).

The fibrous perichordal tube becomes cartilaginous. In the intervertebral portions these perichordal tubes have become larger

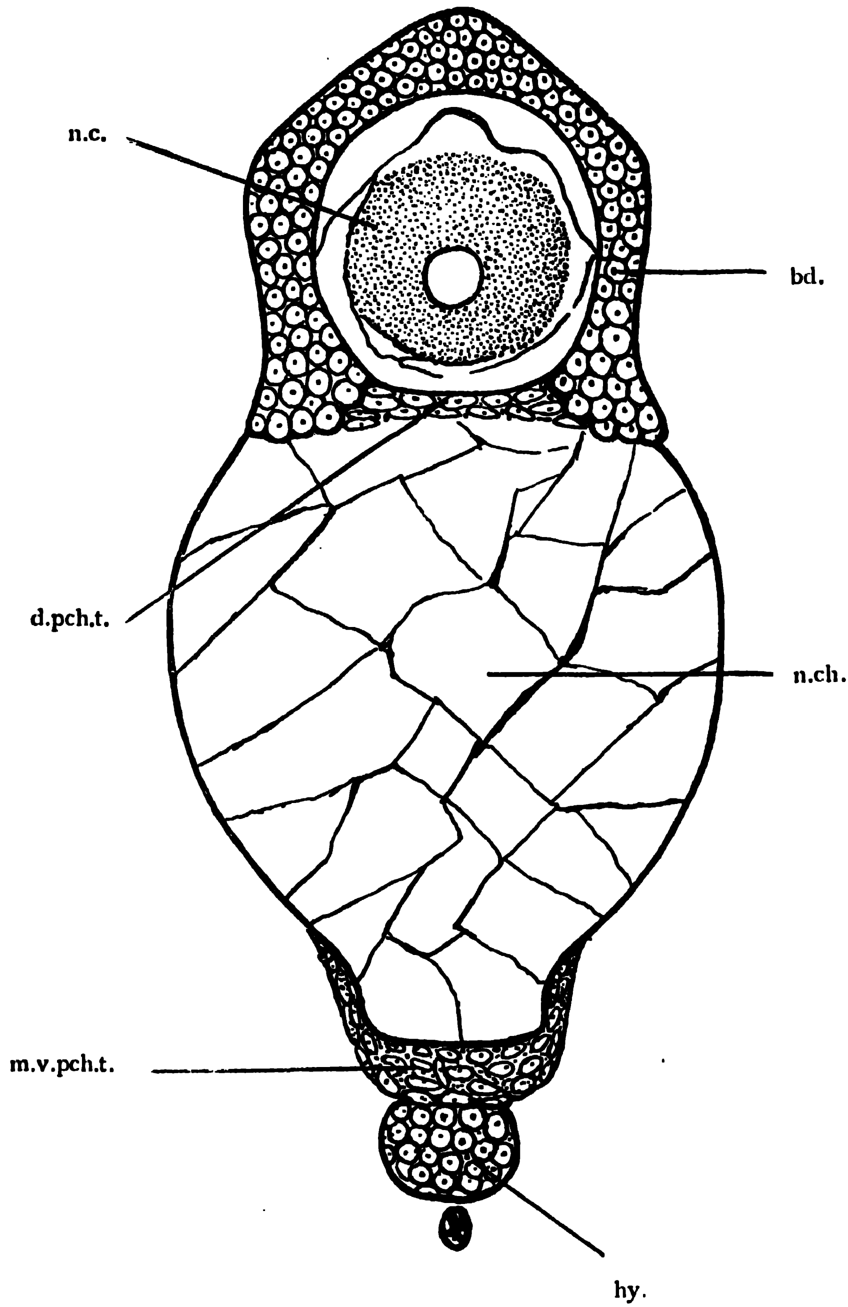

Fig. 10.—Transverse section of the anterior portion of the urostyle of *Xenopus laevis* at 52 mm. stage before complete metamorphosis X 80.

bd., basidorsal; hy., hypochordal cartilage; d. pch. t., dorsal portion of the perichordal tube which is cartilaginous; n. ch., notochord; m.v. pch. t., midventral portion of the perichordal tube which is cartilaginous; n.c., nerve cord.

and have greatly constricted the notochord. As a result of this inpushing the intervertebral perichordal cartilaginous discs become shortened and successive basidorsals are thus closely approximated to one another and a shortening in length of the vertebral column as a whole is effected (Fig. 8).

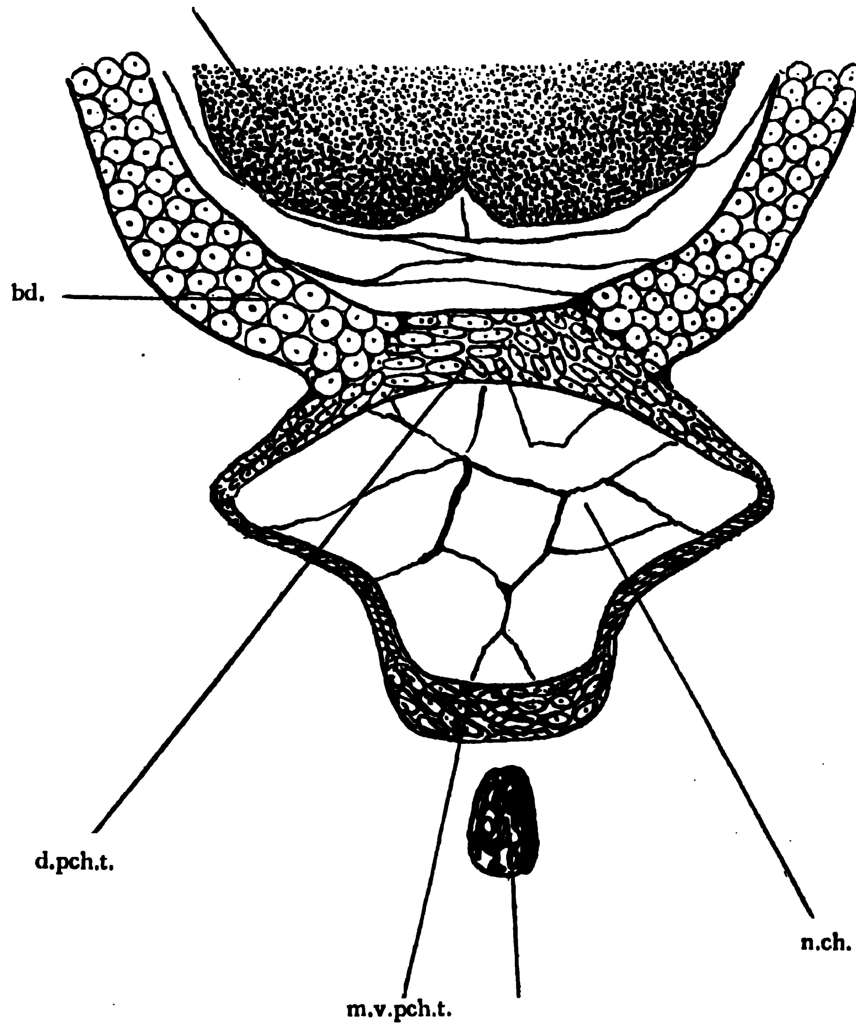

Fig. 11.—Transverse section of a trunk vertebra of *Xenopus laevis* at 40 mm. stage during metamorphosis showing the degeneration of the midventral cartilage of the perichordal tube X 80.

ao., aorta; bd., basidorsal; d. pch. t., dorsal cartilaginous portion of the perichordal tube; n. ch., notochord; m.v. pch. t., midventral perichordal tube; n.c., nerve cord.

This sort of constriction of the notochord is the real cause of the diminution of the length of the animal, since we know that if we constrict an inflated rubber tubing at intervals the total length of the rubber tubing will be less than prior to having these constrictions.

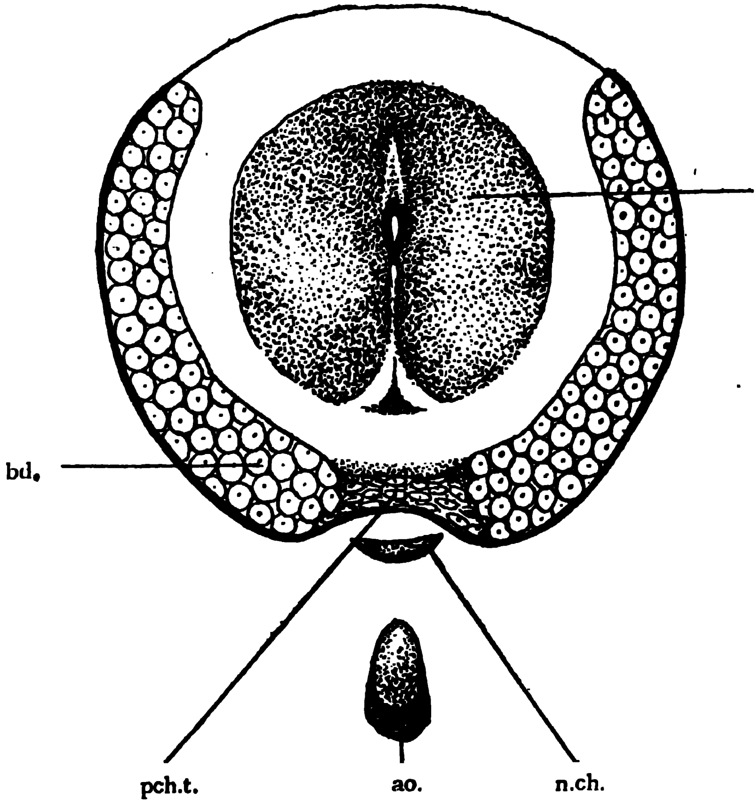

Fig. 12.—Transverse section of a trunk vertebra of *Xenopus laevis* at 32 mm. stage after metamorphosis showing the degeneration of the centrum except the mid-dorsal portion of the perichordal tube X 80.

ao., aorta; bd., basidorsal; n.c. nerve cord; nch. notochord; pch. t., perichordal tube.

The African aquatic toad, *Xenopus laevis*, has a very peculiar mode of life. During its larval period, it is a very strong robust tadpole (Plate II., figs. 1 and 2). With its metamorphosis into adult condition the animal becomes very much dorsoventrally flattened in order to be able to live in the cracks and crevices of the rocks in the water (Plate II., fig. 3). It is interesting to note how

much degeneration should take place in order to reduce the girth of its body. Even the skeletal system should have a heavy amount of degeneration, otherwise it would not be possible for the animal to have a flattened body.

The notochord gets vacuolated, and at the periphery we get the notochordal epithelium. Outside this there are the elastica interna and externa. Mesenchymatous cells surround the elastica externa to form the perichordal tube. At the same time the sclerotomic cells which were aggregated at the dorsolateral corners of the notochord corresponding to each posterior half of the myotome forming the basidorsals. Eventually these basidorsals are chondrified, but are still connected above the spinal cord by fibrous tissue. In the vertebral regions the dorsal portions of the perichordal tube are chondrified. The sides of the tube remain fibrous. Its ventral portion, however, becomes changed into rectangular unsegmented cartilage (Fig. 9). The intervertebral portions of the perichordal tube have grown thick and compress the notochord just beneath the spinal cord, so that the notochord is moniliform in shape. Beyond the ninth arch there forms a mid-ventral cartilage just outside the rectangular unsegmented cartilage of the perichordal tube which is the hypochord of the urostyle (Fig. 10).

In the atlas region the whole perichordal tube is chondrified, forming a ring-shaped centrum. The intervertebral cartilages, which were formed from the dorsal portions of the perichordal tube of the interverterbral portions, are now divided into a ball and a socket. The sides of the perichordal tube and its ventral portion consisting of the rectangular cartilage are also in rapid degeneration (Fig. 11). Ultimately the dorsal part of the perichordal tube remains, so that the basidorsals rest on it (Fig. 12). In the urostyle region the notochord and the perichordal tube also ultimately degenerate and the hypochord presses upwards joining the ninth neural arch (Fig 13).

The hypochord is fused with the tissue representing basidorsals anteriorly which is now chondrified, but in its posterior portion this tissue is lacking, and here the spinal cord is exposed. The

rectangular cartilage formed from the ventral part of the perichordal tube is still persisting beneath the trunk vertebrae and above the hypochord in the urostyle region. The centrum of the first vertebra is cylindrical, the rest flattened.

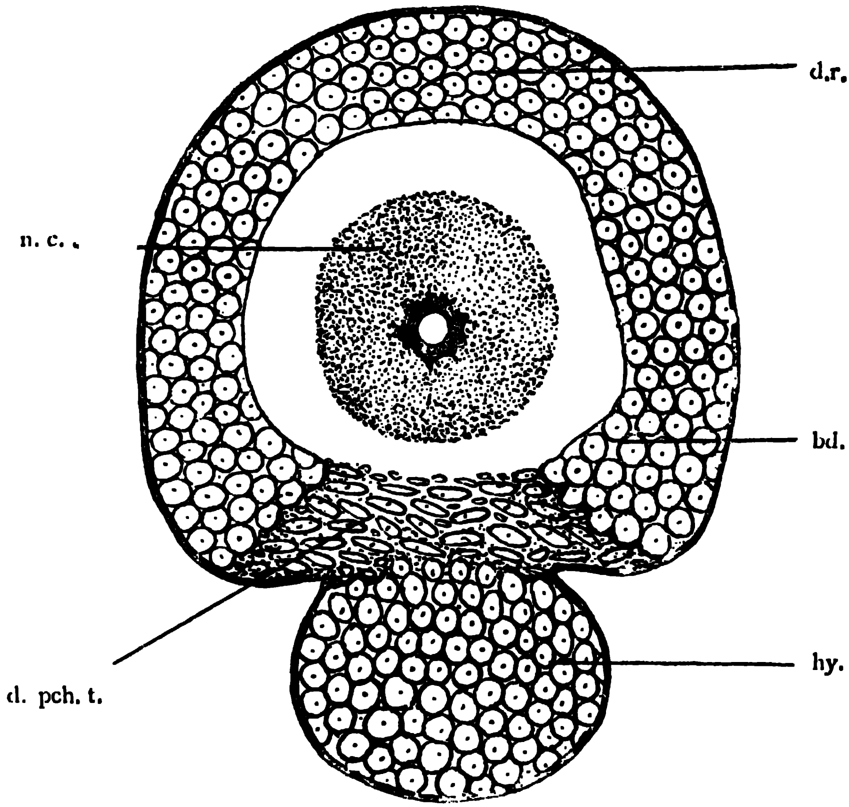

Fig. 13.—Transverse section through the anterior portion of the urostyle of *Xenopus laevis* at 32 mm. stage after metamorphosis showing the hypochordal cartilage in close contact with the ninth neural arch after the degeneration of the centrum X 80.

d. r., dorsal ridge; bd. basidorsal; d. pch. t., dorsal part of the perichordal tube: hy., hypochord; n.c. nerve cord..

The above examples enable us to recognise the utility of the study of embrylology. Such a study has hardly been appreciated by researchers in zoology in India. While systematic study as such has its utility, the deeper one—embryology—is no doubt more essential for the advancement of fundamental knowledge of organic evolution. It has a prompt recognition in all countries and

publications in journals are readily available. Its utility is more apparent. It is only in a few Universities in India where this line of study has been taken up very recently and I hope more workers would come forward to undertake investigations in this direction. Several workers are now investigating in different embryological problems in the Zoological Department of the University of Calcutta.

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EXPLANATION OF PLATE II.

Plate I fig. 1.—A robust tadpole of *Xenopus laevis* before the appearance of limbs. The peculiarity of this is the presence of a pair of barbels and a lung tail, X 2.

Plate I fig. 2.—Almost a metamorphosed *Xenopus laevis* with a short tail. The posterior limbs are much longer than the anterior. The girth of the body is massive and round. X 2.

Plate I fig. 3.—An adult stage of *Xenopus laevis*. The body is very much dorsoventrally flattened. X 3/4.

1

2

3

Need for a Hydraulic Research Laboratory in Bengal

By M. N. Saha (Allahabad).

[Within the past ten years (1922-1932) large regions in Bengal have been visited by two catastrophic, and many other minor floods, causing widespread havoc and distress amongst the rural population. Acharyya Prafulla Chandra Ray has been foremost amongst the leaders of the country in the matter of organisation of relief for the flood-stricken people. He identified himself so thoroughly with this work that Mahatma Gandhi jocularly describes him as the "Doctor of Floods". When the writer of this article was asked to contribute an article to the Jubilee Volume which is to be presented to the Acharyya on the happy occasion of his seventieth birthday, he thought that nothing could be more pleasing to him for this occasion than a scientific analysis of the causes of these catastrophic floods and other attendant evils, such as malaria and erosion, and suggestion of measures for combating them. The readers may not agree with the writer's findings and opinions, but he will consider his labours amply repaid if this article induces them to serious thinking about these devastating calamities on independent lines of their own. It may be added in this connection that in preparing this article, the writer has drawn very freely from articles by Rai Bahadur Dr. G. C. Chatterjee, M.B., the eminent bacteriologist, who has rendered signal service to the country by organising the Co-operative Anti-malarial Society and by calling attention to the acuteness of the problem in several thoughtful contributions. Thanks are also due to some friends who prefer to remain unknown.]

The need for a Hydraulic Research Laboratory in Bengal for the study of her river problems has been long emphasised by experts in this line. We refer to the opinion expressed by Sir F. Spring, C.I.E., Chief Engineer to the Government of India, in 1903, who

was responsible for the design of a large number of railway bridges, the most well-known being the Sarah Bridge over the Ganges. Bengal is a land of rivers, and her prosperity and health depends entirely upon the proper behaviour on the part of her Great Rivers and their tributaries. It is well-known that in the past change of river courses either by men or by Providence has been attended with dire consequences. In the fifteenth century, the city of Gaur, which was the capital of Bengal for over a thousand years, and is reputed to have possessed a population numbering over a million, was completely laid waste by a terrible marsh-fever, which was due to the diversion of the course of the Ganges and creation of an unhealthy marsh in the vicinity of the city. Within the last hundred years, whole districts have been ravaged by malaria and black-fever, and according to competent authorities, these outbreaks can be ultimately traced to changes in the course of rivers and other waterways by men or by Providence.

Thus the Atraye and the Karatoya basins in North Bengal comprising the districts (partly or wholly of Jalpaiguri, Bogra and Deenajpur) have been ravaged by malaria owing to the diversion of the waters of the Teesta river to the east between the years 1768-1825. Central Bengal which enjoyed a salubrious climate during the whole of the Moghul age and early part of British rule is now fast becoming a wilderness owing to the blocking of the headwaters of her river systems (the Bhagirathi, Jelanghee, etc.) by sand deposits, and blocking of the inland waterways by railway bunds and bridges. West Bengal, which was as healthy and properous as Central Bengal upto 1850, has been converted into a malaria-stricken wilderness by the construction of railway bunds, and blocking of the headwaters of the Damodar and her tributaries.

It is rather strange that in these days when Science is being applied to every walk of life for increasing human comfort, this problem of river control has never been scientifically studied in this country. The Government is in the habit of boasting of the amount of great engineering works of public utility for which it has been responsible. The inner history of these works is not so well-known to the public. It was very lucidly exposed

by Sir F. Spring in his "River Training and Control", published nearly thirty years ago.

The absence of any organisation for recording experience or original Research in connection with the physics of Great Rivers

1. "As trustees of so fine a property as this—canals and railways, it might not unresonably be expected that the State would see the importance of devoting a comparatively small annual appropriation to original research, on lines likely to be productive of a good return for the expenditure, in the form either of reduction in the first cost of its public works or of their safety and their economical up-keep when built. *Heretofore there has been no pretence of organising any such research* in connection with the engineering of the canals and railways of India. *Engineers have gone on blundering, benefiting, rather by chance than by design, by the experience of their predecessors, and each considering himself lucky if he escapes disaster at the hands of the tremendous forces of nature—amongst which some of the most potent for good or evil are the great rivers—with which he has to struggle.* Until quite recently there has been practically no encouragement, and indeed at times there has been discouragement, to men to publish their experiences. And so, in spite of having perhaps as fine a body of scientific engineers as any country, not excluding France, has in its employment, and in spite of this body of public servants having carried out daring and extensive works of a certain character, chiefly, in connection with the great Indian rivers, on a scale unparalleled elsewhere, the state possesses the most meagre record of the history of the works carried out so successfully by its employees. In putting the chapters of this book (River Training and Control by Sir, F. Spring) together, the author found extreme difficulty in ascertaining what had been done, what difficulties had been encountered, and how these difficulties had been surmounted, and it has needed the expenditure of nearly a year of research to enable him to offer to the Government of India the advice, contained in the foregoing chapters, in regard to one limited phase of the engineering of great rivers. . Time will show the value of that advice, and doubtless further experience will modify the practice recommended. But meanwhile *the author would urge on the Government the importance, from a mere money point of view,*

of insisting on the maintenance of an intelligent record of the history of such works as those dealt with in the foregoing chapters."

The Consequences of lack of Organisation

2. "With regard to the physics of long reaches of the great rivers, the author is not in so good a position to speak. His special experience has been gained rather on short lengths of such rivers in contiguity to his works. In view of his practical inability to regulate the flow of great lengths of such rivers he has viewed the inimical consequences of the irregularities of their flow, in the form of deep and dangerous scour, as requiring to be fought by sheer irresistible force rather than by coaxing. This necessarily must be the attitude of the engineer in charge of great bridges, and perhaps to a lesser extent of those in charge of great irrigation weirs. But *they ought not, for that reason, nor ought the State, to lose sight of the importance of endeavouring, by consistent, logical and well organised research, to learn something more definite than is now known about the physics of long reaches of rivers. A* perusal of chapter III and XXI, as well as of Mr. R. A. Molloy's Technical Section paper No. 118, will suffice to show how blindly, heretofore, in the interests of the residents on their banks, men have been fighting against the ill-will of some of the great rivers; whether on behalf of the maintenance of levees* whereby devastating floods are excluded from great inhabited areas; or for the conservation of the heads of inundation canals on whose integrity the welfare of many thousands of people is dependent; or *in the interests of riparian cities whose obliteration would be a blot on the administration of civilised and intelligent rulers. It is difficult to avoid the conclusion, after perusal of chapter XXI, that for lack of adequate knowledge, the engineers concerned with the interests of the inhabitants of the valley of the Indus have been obliged to work more or less in the dark in their fight with that river, and to make matters worse it has constantly happened that, owing to the climate, to the exigencies of public service, no sooner does one engineer get some small inkling of the tricks than he is replaced by one with all*

* This is a word of French origin, which is used in the U.S.A. to denote embankments.

his experience to gain; and in six months he, in turn, is replaced by somebody else whose experience of the river has perhaps been limited to crossing it. How, under so haphazard a system, anything gets done at all is a marvel; and instead of being surprised at £100,000 worth of work having been wiped out, the State may congratulate itself if the loss is not double. However there is always the satisfaction, in the case of such expenditure as that dealt with in chapter XXI, that the whole of the money has remained in the country, and that if the taxpayer takes money out of his coat pocket only to put it into his waistcoat pocket he can always pick it out again, or its equivalent."†

Suggestion for the appointment of a River Commission

3. "*The appointment, for say 10 years of a River Commission not merely for the Indus, but for the organised study of the physics of great alluvial rivers generally, would be a service to civilization and an act worthy of a great State.* The Mississippi Commission have done a great deal, but their experience is not to any great extent applicable to Indian conditions. The experience of the engineers of the Rhone and the Danube and other European rivers, though valuable in its way, is even less applicable to India than that gained on the Mississippi. Mr. R. A. Molloy's attempt at a theory, as summarised very inadequately in chapter III, is the first that can be characterised as a scientific generalization of the river problem that the author has heard of in India. And even this is based on inadequate data, picked up anyhow, amidst the multifarious duties falling to the engineer to a system of inundation canals. There is need for a thoroughly scientific location, and for the automatic reading, of gauges at hundreds of places, for several years, along great lengths, selected with care and knowledge, of several of the great Indian rivers, also of some systematisation of the surveys which usually are undertaken on these rivers, and of the making of fresh surveys specially designed to elucidate facts, also of an organised system of soundings and sections. The engineers in charge of the work must steadily keep in view the ultimate object of it, and must not make a survey merely for

† This is not quite right; the money so spent goes to the pocket of British manufacturers who supply most of the materials.

the sake of a section. The object in view will be: To present to the scientific world, and especially to the engineering world, and more particularly to the engineers of structures in India that are subject to fury at the hands of the great alluvial rivers, such an explanation of the probable action of these rivers, under various circumstances, as will allow of such action being anticipated; and especially, to enable the engineer to utilise fully his knowledge of the rivers, so that he may make a servant of it, instead of being as it is now very often the case, his master. There can be no doubt at least from the author's point of view—*that more money has been wasted, for want of just such knowledge as a River Commission might provide, than would have sufficed to pay the entire cost of it many times over.* Certainly, so far as training works in connection with bridges are concerned, in rivers of the class with which the author has chiefly concerned himself, most engineers responsible for such works would probably admit that whether they spent money unnecessarily as an insurance against their inevitable lack of scientific data, or that they were unduly economical, with either disaster, or heavy annual recurring expenditure in after years, as the result. Thus looked on from the lowest or merely commercial standpoint, the establishment of such a Commission ought to be highly remunerative."

This long quotation speaks for itself. *It is a very powerful argument in favour of establishment of not only a River Commission but also of a laboratory for research in River physics.* If anybody could have calculated the total damage, which is consequent on the haphazard policy of the Government and the consequent errors of the Engineers for which they cannot be held responsible, for they were working under orders, I think the same would have run to millions of rupees. This may be attempted on a future occasion, by a competent economist.

Meanwhile it is a matter of pity that neither the Central Government nor the Provincial Governments excepting the Punjab Government has thought it necessary to profit by Sir Francis Spring's advice. To repeat Sir Francis's words 'In the meantime engineers have gone on blundering and we may add committing the country to huge financial losses'. Though Bengal had not had her Back Bay Scheme, or anything like the Mundi Hydroelectric

Scheme, she had to pay a bill of a crore of rupees for the Grand Trunk Canal Scheme, which was planned and launched by the late Chief Engineer, but was fortunately stopped in the earlier stages.

Much of this unnecessary loss can be stopped if the Governments took some action on Sir F. Spring's advice given to them thirty years ago. An examination of his remarks shows that his scheme may be divided into two parts :—

1. **Establishment of a River Physics Laboratory for study of the problems of River Training, Floods and Irrigation and Navigation in Bengal.**

2. **Establishment of a Field Service which will undertake a hydrographical survey of Bengal, including relevant studies in topography, precipitation and other geological factors. This corresponds to Spring's River Commission.**

Sir F. Spring laid more sress on (2), but I submit that (1) is equally or more necessary.

The idea of a River Physics Laboratory is not new. England has no laboratory of this kind, excepting a recent Ship-building research laboratory attached to the National Physical Laboratory at Teddington, because England has no river problems on a scale as we have got in India or other countries of the continent. Hence English engineers of the past generation have not been alive to the necessity of having such a research laboratory. But every other civilised country possesses a number of private and public laboratories attached to Technical High Schools or Universities. I give a list of such laboratories which is by no means exhaustive.

List of Hydraulic Research Laboratories of the World

Laboratories			Directors
1. Germany—			
Berlin (Charlottenburg)		...	M. Grantz
Dresden	...	...	H. Engels
Dantzig	...	...	R. Winkel
Brunswick	...	...	Max. Moeller
Karlsruhe	...	...	Th. Rehbock

Laboratories		Directors
Wilhelmshaven ...	...	W. Krueger
Munich ...	...	D. Thoma
Goettingen ...	...	F. Prandtl
2. Austria—		
Vienna ...	...	F. Schaffernack P. Forchheimer
Graz ...	...	A. Schoklitsch
3. Czecho Slovakia—		
Brun ...	...	A. Smrcek
4. Hungary—		
Budapest ...	...	A. Rohringer
5. Soviet Russia—		
Leningrad ...	...	Timonoff
Tashkend ...	...	...
6. Sweden—		
Stockholm ...	...	W. K. A. Fellenius
7. Norway—		
Trondjem ...	...	O. Heggstad
8. France—		
Grenoble ...	...	
9. Italy—		
Milan ...	...	Fr. Marzolo
Padua (Roy. Eng. School)	...	E. Scimemi
10. Holland—		
Delft ...	...	J. T. Thijsee

11. United States of America—

(The American Laboratories are sometimes attached to Universities, sometimes they are managed by private organisations).

Cornell University, New York		J. Freemann
State University, Iowa	...	P. Nagler
Worcester Polytechnic, Worcester ...	...	C. Allen
Alabama Power Col., Birmingham ...	...	A. Winter

This list is by no means complete. For example, in Italy there are important laboratories at Rome and at Pisa attached to the Royal Engineering Schools. Details of French laboratories are lacking, but there are important hydraulic laboratories attached to the University of Toulouse, and one at Bordeaux.

In Germany, many technical high schools possess more than one laboratory, each devoted to a separate branch.

The River Physics Laboratories of the World

Germany has been the pioneer, as in many other enterprises, in the development of these laboratories, and the activities of her trained experts and scientists have done immense good to the development and improvement of her inland waterways, harbours, canals, and to the dwellers of the riparian tracts. There are permanent Rhine river and Danube river commissions composed of experts (*not politicians or officials*) of different countries through which these rivers pass. After the Great War, the Hapsburg Empire has been dissolved but the Danube River Commission continues its activities at Vienna.

Italy, the first country to feel the invigorating atmosphere of the Renaissance, was the first amongst the modern nations in tackling problems of River Training, for even in the seventeenth century, her great pioneers of science, Leonardo da Vinci, Galileo, Torricelli devoted their time and energy to the problems of the river Po flowing through the rich plains of Lombardy. They were the first to develop scientific embankments. But like many other efforts of the Italians, her early start was nullified by the unsettled political condition of the country and by long-continued foreign domination. Even the modern science of river physics owes its inception to an Italian. The following passage is taken from Freeman's book on "Hydraulic Research Laboratories":

"In 1764, Paul Frisi, Professor of Physics at the University of Milan, wrote his celebrated treatise on the nature of torrent and gave great credit to the work of Guglielmini, published half a century before.

"Frisi paid his compliments to the mathematicians for

the absurd results they had reached by reasoning from a priori grounds and declared that hydraulics is not a branch of mathematical science, but is a branch of physics. Although to-day its conceptions and its science appear crude, this work of Frisi was so highly regarded that *more than a century ago it was translated into the English language at the cost of the English Government for the use of its engineers in India, who even then had begun their gigantic water-storage and irrigation works.*"

The Engineers in India follow antiquated methods

From Spring's remarks, it appears that the engineers in India are still following the two century old treatise of Frisi, and have gone on blundering with their gigantic storage and irrigation works, and presenting gigantic bills to the Public Exchequer for their haphazard way of working. There have been laudable attempts on the part of several engineers to study the problems scientifically, e.g., Cunningham's studies at Roorkee, and Molloy's studies in the Indus River, and Spring's works at Sarah. But for the most part of their work, these studies have neither been sustained, nor preserved adequately. There is no indication that they have profited by the lessons obtained at the great European Laboratories.

Russia :—The case of Russia merits attention. The Czarist Government was busy with wars, ordinances, and suppression of those human pests, the Socialists, and Labourers and Terrorists. But the Bolsheviks have taken very early steps of organising two of the biggest hydraulic Research Laboratories in Soviet Russia, one at Leningrad, and the other at Tashkend in Central Asia, in which the services of great German and Austrian experts were requisitioned. According to the testimony of Dr. Schaffernack, Director of the Vienna Laboratory, whose services were requisitioned by the Soviet Government, the Tashkend Laboratory is the biggest and most sumptuously fitted in the world. It will deal with the problems of the Amu Daria and Syr Daria basins. These were great centres of population when the country was Buddhist from the first to the eighth century A.D., and also during Mahomedan times up to the sixteenth century. But

centuries of Turkish, Moghul and Russian misrule converted the country into a desert. The Soviet Government intends to restore the country to its pristine prosperous state, by undertaking huge river training works, but preliminary to such work, they have built a large River Physics Laboratory for scientific study of the problem.

Study of River Physics in America

America comes to the opinion that the Physics of Rivers should be first studied in the laboratory before any great engineering problem is undertaken.

America :—In the U. S. A. one meets with river problems on a scale which are rivalled only in India. The Mississippi is quite as difficult to manage as the Ganges. So long, the care of the Mississippi was entrusted to Army Engineers, who went on strengthening the levees (embankments) in order to keep the flood within the embankments. They declared proudly in 1926 that the rivers has been tamed once for all, but the river belied their sanguine hopes by bursting through the embankments in 1927, and creating the most devastating flood ever known. Since this incident a strong feeling has been growing that the Physics of the River should be first scientifically studied with laboratory models before any further engineering work on a huge scale is undertaken, and through the efforts of J. R. Freemann, a number of research laboratories have been established. Regarding the U. S. A., Freemann says in his introduction to Hydraulic Laboratory Practice —I quote his opinions fully because his remarks apply to the situation in India :

> "As one delves into the history of the development of hydraulics as a science, it becomes plain that those who observed natural rivers far apart and not subject to experimental control, mostly failed to discover the laws that controlled their movements of water and sediments, and that those who treated hydraulics as a branch of pure mathematical research instead of as a branch of experimental mathematical physics, mostly

> got lost in their a priori theorizing. It becomes plain that those who used the Laboratory method made most of the useful discoveries."

"Although the name 'hydraulic laboratory' is modern, the underlying idea is old. Apparatus and methods answeing to this name doubtless were used by da Vinci, by Galileo, perhaps by Archimedes. In its earliest forms the laboratory was extremely simple, a tank with an orifice and a measuring basin; or a small water course, like that used by Fargue in France, within which the motion of small streams of water could be studied, and the laws of of motion for rivers inferred. Within recent years, the name has come to suggest a special building, filled with many kinds of apparatus, pins, measuring tanks, weirs, channels with plate glass sides, special photographic cameras, small-scale models of channels and structures, spouts, meters, manometers, and glass tubes.

"The most powerful instrument for research in the latest and best laboratories for studying river structures and water turbines has come to be the small-scale model,* used with an understanding of the mathematical principles of hydraulic similitude. By these methods of hydraulic similitude many great problems of highest importance and involving quantities and forces on a grand scale can be taken from the great out-of-doors into the laboratory and solved by means of experiments upon a model having linear dimensions only one-tenth or one one-hundredth part of those in the original channel or structure.

"However, when one takes large problems from the flowing river, or tide-swept harbor, into the laboratory, it is of the highest importance that comparison between the original and the model be maintained step by step, and that traps be set in which to catch and measure every conceivable source of error, because some of the

* Even the British are gradually coming to realize the value of researches of this type. The Shannon River hydroelectric project in Ireland was studied in 1927 with the aid of laboratory models in Charlottenburg, and an English company in the Malay Peninsula is getting their projected hydroelectric scheme at Chenderoh studied at the Stockholm laboratory. Further, mention may be made of Prof. Gibson's model experiments in the Mersey River. Four Reports have been published by the British Government.

relations of cause and effect in rivers in shift or current and in behavior with sediment are extremely delicate and elusive. Although the forces which control the movement of particles of sediment may be as delicate and variable as those which control the dance of the individual motes of a sunbeam, all are subject to definite laws; and while the paths of individual particles may be beyond our grasp, the general mass-effect is commonly found subject to analysis and control. The laboratory can tell us how to predict and how to control these mass effects.

"*Observation on natural river has proved a slow and almost hopeless road for one who desires to discover the laws through which rivers can be controlled and regulated, or by which they can be made to dig their own channels where man wants them; or to one who desires to learn how to cause rivers to sustain their burden of silt and sediment and carry it to the sea.* There has been a painful lack of precision of measurement throughout nearly all the vast mass of recorded observations, and a general failure in the attempts to apply rigorous mathematics and devise precise formulas, largely because of lack of precise data from precise observation.*

"Often, it has been said by engineers and others that 'Nature prefers a gently curving course for rivers,' and therefore man should curve his channels for navigation, or for flood relief, or for leading a volume of water to a power drop. This is more the expression of a poetic dream than a careful statement of facts.

"It is a wise provision of nature that has caused rivers to seek meandering courses, because there fertile plains are slowly built up from the sedimentary material brought down from the erosion of the mountains. Man commonly desires channels of a different order, straight and deeper, and better adapted for navigation.

"Sometimes in engineering practice there are good reasons for curving the course of a channel, as for causing the swifter current near the concave shore to maintain a well-defined

* These remarks justify the plea for the establishment of a research laboratory for the study of river physics. A mere river commission as suggested by Spring would not improve matters much.

channel for navigation, or for concentration of deposits at 'cross-overs' between reversed curves; but commonly the strongly curving channels may be far from the best for purposes of navigation or flood control.

"Sometimes there is need of quicker discharge of floods, and sometimes need for detention. Often it is important to control the movement or deposition of sediments ranging from boulders and coarse gravels brought down by Alpine torrents to the finest sands or to the colloidal silt. We can best find out how to call the great forces of nature to our aid, by means of the laboratory model, checking up, step by step, and comparing the action in the model with observations on the river or harbor.

"One must be extremely cautious about generalizing from the scanty data and the uncertain parallels of observations upon rivers, in which many distinct causes combine to control flow, erosion, and sedimentation. A confusion of causes prevents accurate deduction. On the contrary, in the laboratory these diverse causes, such as burden, or kind, or coarseness of sediment, roughness of bad curvature, velocity, turbulence, salinity, temperature etc., can be singled out, controlled, and varied on at a time.

"I have long been strongly of the opinion that by means of a patient study of this kind, with field observation and laboratory experiment continually supplementing one another, we can learn to deal more boldly and more successfully than heretofore with many of these problems of changing the course of large rivers, and sometimes can straighten them with great advantage, and that the forces of nature can be invoked to perform a large part of this work.

"I believe that even the problem of straightening the Mississippi may be solved by long-continued experimentation in laboratory and river, showing how its great bends, like those near Grenville, may be changed to far shorter, gentler curves, thereby giving a greater declivity and greater scouring force to the current, which then will dig deeper its river bed, so as to carry great floods within banks with lower levees, perhaps ultimately with no levees at all in certain long reaches and with far greater safety to life

and property than now, and without need of any such vast spillways* as are now being proposed. Also it is my belief that the flood surface can be lowered by lessening the height of the cross-over bars through narrowing the river at the cross-overs, by means to be worked out partly in laboratory and partly in the field; also that as the culmination of certain lines of research, one may learn how to build cheaper, quicker, and more permanent riverbank revetments, and how to keep the South Pass† open without constant dreadging.

"Last summer, at Karlsruhe, I was told that with each practical major problem that had been taken into their river-structure laboratory, the saving in structural cost due to the information thus gained had been more than equal to the entire cost of laboratory building, apparatus, and research. At Charlottenburg, and elsewhere, I gathered that laboratory research with the aid of small models had been similarly profitable.

"Personally, I have little doubt that a suitable river structure laboratory, in skilful hands in the United States, could be made to pay dividends of a thousand per cent per year on its cost. One has only to study the vast appropriations for river and harbor improvement made by the United States during a term of years e.g., two millions of dollars wasted in futile experiments on the Mississippi for narrowing the channel by permeable dikes, about 600,000 dollars wasted along the lower Colorado, and nearly twenty millions spent before success in trying to open the South Pass mouths of the Mississippi for big ships, or to consider the problems of the California Debris Commission or the present conditions along the Missouri River, to see that such a statement is not extravagant.

"Ancient Rome had important river problems. The question of cutting off a river bend in the Tiber, which threatened Rome, was gravely discussed by the Senate and dropped for the profound reason that "Nature understood what was best when it formed the

* Spillway—a side channel for carrying excess flood water.

† The point at the head of the Mississippi delta.

river in its present shape".* Two thousand years later, Professor Rehbock of Karlsruhe, by means of experiments upon five successive laboratory models, showed how a similar problem could best be solved by a short cut across the neck of a horse-shoe bend from which the backwater threatened Nuremburg in times of flood. Meanwhile fifty years or more ago, by methods of "cut and try", German engineers had cut out the great bends and concentrated the flow of the Rhine into a single channel, between Basel and Mannheim, shortening the river 23 per cent with great advantage to all concerned.

"Strange to say, in view of the size of our rivers and the importance of the problems they represent in navigation and flood control, there is not yet in America even one laboratory well equipped for the study of river problems; and still more strange, the military engineers to whom American river and harbor problems have been given to keep them employed in times of peace, have not yet awakened to the utility or understanding of research of this kind. They are still in the "phlogiston age" of applied science.†

"That in America we have not yet even one river-flow laboratory camparable with those of Germany is strange, because the rivers of the United States present some of the most important hydraulic problems that can be found anywhere in the world."

What is the object of a Hydraulic Research Laboratory

The object of a Hydraulic Research Laboratory are thus defined in Freemann's book :—

"(*a*) Those designed primarily for purposes of instruction at engineering colleges.

"(*b*) Those designed primarily for research; some established by National Government, others by builders of hyraulic machinery.

"(c) Those in which both purposes are combined."

* The result was that Imperial Rome decayed through outbreaks of malaria.

† It appears that the U.S.A. has to pay her toll to vested interests as we are compelled to do so in India.

The work done at these laboratories are of a multifarious nature :—

1. "The ordinary hydraulic laboratory, commonly a temporary installation of apparatus, designed for giving once for all, for use in the routine work of the engineers, accurate constants to be appiled in formulas for computing the discharge of water from orifices, nozzles, and weirs or various shapes under various heads, or for estimating the discharge of pipes, conduits, and open canals under a given hydraulic gradient, or for giving the height and range of jets under given heads."

2. "The general laws or formulas governing the motion of water for each of the above problems are tolerably well-known, but with the progress of time more precise coefficients or constants are required."

3. "The 'Flussbau' or river-structure laboratory, designed as a permanent structure with facilities for various set-ups of apparatus, for establishing hydraulic laws applicable to special problems within the field of the civil engineer, particularly those which deal with the improvement of rivers and harbors (involving erosion, transportation and deposit of sediments), the building of dams and the out-of-doors accessories of water-power development, and the storage and distribution of water for municipal supply. This type is proving useful in the preparation of designs such that obstruction of sluiceways by ice or logs will be minimized, that floods will be most readily discharged."*

4. "The water-turbine laboratory, especially designed for helping the mechanical engineer in the development and perfecting of various types of turbine water wheels and centrifugal pumps, and adjusting a design to give the best practicable efficiency for a particular head and speed of revolution, and for various percentages of full discharge."

5. "The naval tank or laboratory, designed for providing the naval architect with means for studying the resistance to the propulsion of ships or canal boats of various forms at various speeds by experimenting upon

* The formulae are only empirical and hold only for the rivers from which the observation data were compiled. The main defect of the hydraulic laws are that they have been defined from conditions of steam-line flow whereas in all the above problems we have to deal with turbulent flow. The dynamics of turbulent flow have been studied in recent years by Prandtl and his students at Goettingen.

a small model of the ship, and for improving the design of screw propellers by means of tests on small models."

The hydraulic research contemplated by Indian engineers is a very small part of the above programme. We again quote Sir F. Spring :—

"The river training works in India have so far been only directed towards the guiding of a wandering river between a fixed pair of abutments whether of an irrigation system or railway bridge."

Problems of Rural Bengal

This is a small part of what a full programme in Bengal ought to be. In Bengal the problems are stupendous. The Ganges, though it is a much shorter river than the Mississippi, discharges more water at Sarah than the Mississippi near the head of its delta. No reliable estimate of the discharge of the Brahmaputra is available, but its discharge is supposed to be much larger than that of the Ganges. These huge discharges, which are timed at certain intervals, take place over an area which is smaller compared to the Mississippi basin. The Damodar system stands by itself and should be treated apart. The discharges of all these rivers, their periodic variations, the amount of silt brought by them, the distribution of water in the country, study of the precipitation data for each basin—all these factors must be accurately studied, before any great engineering work (River Training, Railway bridges and bunds, Excavation of old channels, Flood Control, Canalisation for irrigation and navigation) is undertaken. The plans must be tested in the laboratory with the aid of models a number of times, and advantage should be taken of the accumulated experience of the western countries. This has not been done in the past and even in the present days great enginneering schemes are being launched without proper study.

It should not be supposed that the problem is vital to Central and Western Bengal alone. Their former prosperity can certainly be restored if the Government acts with a will on my suggestion. Eastern Bengal, which is now prosperous and mostly free from malaria, should not continue to live upon a false sense of security.

Her prosperity is due to the facts that every year she is washed by floods, which deposit fertilising silt on her soil and carry away the germs of malaria, but history has taught us that the rivers of Bengal, either due to slow earth-movement or delta-building activities periodically oscillate between wide limits, and if any forsakes an old channel and scoops out a new one, the old basin becomes the centre of malaria and black-fever. Coming from East Bengal, I have seen prosperous villages in the Manikganja and Tangail areas converted into wildernesses by sudden outbreaks of malaria.* The cause is not difficult to gauge. It happens that a big river like the Dhaleshwari goes on depositing silt in the country-side round populous villages, and raising its level. After some time, the level of the villages becomes lower than that of the fields, and dead pools are formed within the village. Then suddenly malaria breaks out with unprecedented violence on an unsuspecting population.

If the river be not controlled, and the people are not taught how to live in such areas and keep their pools clear, Eastern Bengal may be subjected to the same devastating epidemics which have ruined Western Bengal. The need for scientific study of the physics of Rivers is an All-Bengal and integral problem, which cannot be undertaken piecemeal.

Forces of Nature can be controlled

There seems to be a school of opinion that the forces of Nature with which the engineer has to cope in the training of the Rivers of Bengal are of such stupendous magnitude that it is futile to make any attempt in interfering with them. Such opinions constitute very handy excuse for the policy of 'Laissez Faire' which has so long been followed, but it seems more to be due to want of acquaintance with the actual problem than to any

* Some years ago, the large and populous village of Suapur in the Manikganja sub-division, which has given to Bengal many sons eminent in public service and other fields like the late Mr. K. N. Ray, and Rai Dinesh Ch. Sen, was ravaged by a sudden outbreak of Malaria carrying off about one-third of the population in course of one single year.

well-considered reasoning. Many eminent engineers who have studied the problems first-hand do not share in this opinion. The greatest change which took place in the river systems of Bengal is the diversion of the Brahmaputra from the east of Dacca to the west. This was started by a catastrophic flood in headwaters of the Teesta river in the year 1736, but it took about half a century to be completed. This catastrophic change, which is responsible for many evils of the present times, could be easily prevented if it were attended to in proper times. This is the opinion of an eminent engineer, Sir John Benton C.I.E., once Chief Engineer to the Government of India, who in a discussion on the Sarah Bridge, remarked as follows :—

"It was stated that the Brahmaputra now passing down the Jamuna river, moved 70 miles westward in the 20 years 1805-1825, in all probability this great change could have been prevented, and at no great cost, provided works had been undertaken at a sufficiently early date."

Wilcock's plans for the Revival of Central Bengal

The other great change which has taken place since 1776 is the gradual silting up of the headwaters of the rivers Bhagirathi, Jelanghi, and Mathabhanga which used to water Central Bengal. This has happened under the very nose of the Government. It has rendered Central Bengal a land of dead rivers, and subject to devastating outbreaks of malaria. It was the most prosperous part of Bengal during the Moghul age, being far richer than Eastern Bengal, but now the productivity of the soil has fallen off by about 45%. According to Sir W. Wilcocks, the eminent engineer to whom Egypt is largely indebted for the Assouan dam and the resuscitation of her agricultural prosperity, the rivers in Central Bengal can be revived, and the prosperity of the country can be restored by clearing off the headwaters of the Mathabhanga, and subsequently when the country becomes rich by erecting an Egyptian barrage across the Ganges 11 miles down stream of the Baral head. According to this authority this barrage will head up the waters of the Ganges by about 7 feet for hundred miles up stream, and cause it to send a large volume of its excess water down

the rivers of Central Board. The work is estimated to cost 18 crores of rupees. Another advantage of such a scheme will be that less water will pass through the over-congested Padma, which is now causing widespread havoc by its erosion. Already half of the historic Vikrampur area is washed away. The waters of the Brahmaputra alone are more than sufficient for Eastern Bengal. A scheme like this ought to be studied for years in the laboratory with the aid of successive laboratory models and other data, before it is seriously taken in hand. In the interest of the country such work should be undertaken, as it promises to rid Central Bengal of the pest of malaria, and restore the *pristine prosperity of this rich Silk Belt Area which excited the admiration of Bernier in the seventeenth century.* It will also rid Eastern Bengal of the periodic catastrophic floods which are due to the blocking of the Brahmaputra waters by a simultaneous rise in the Ganges. The Flood of 1931 alone caused a damage of not less than eight to ten crores of rupees to the poor people of Eastern Bengal, and this alone justifies the small expenditure on a River Physics Laboratory, which may cost an initial sum of Rs. 5 lakhs and a recurring expenditure of about a lakh of rupees.

River Problems of Western Bengal

The problems of Western Bengal stand by themselves. As Sir William Wilcocks and Dr. Bentley have very convincingly showed, the decline of this part in health and prosperity is due to the blocking of the Damodar and her branches by the bunds and ~~canals erected to safeguard the E. I. Ry.~~ Wilcocks finds a surprising parallel between the fanshape alignment of the old Damodar branches and the alignment of the Cauvery system in the Tanjore district of Southern India. The coincidence, according to him, is not fortuitous, but must have been due to immigrants from Bengal who carried with them the knowledge of the irrigation of the Damodar area to South India before the Christian era. The theory is not improbable in the light of what we know of the historical events of those periods. At any rate, both Burdwan and Tanjore formed the richest districts of India in 1815, and com-

paring the two, Hamilton wrote in 1815, "In productive agriculture Burdwan stands first and Tanjore second." What has happened within the last hundred years is well-known. In 1831, when the Cauvery works began to give way to ravages of time, Sir A. Cotton, engineer, courageously undertook to restore the old anicut across the Cauvery erected by the old Hindu kings, and distribute the waters evenly in the delta. It is unneccessary to give a detailed account of his work, suffice it to say that by erecting a new anicut (the upper anicut) and clearing up the headwaters of different branches he was able to head up the waters for a considerable length upstream, and cause the waters to distribute evenly in the delta. The prosperity of the delta remained unimpaired and it is now not only more prosperous than Burdwan, but entirely free from malaria.

The opposite process was undertaken by engineers in Burdwan. This was due to their dread of the Damodar. The devastating flood of the Damodar which occurred at intervals of 30 or 40 years was a thing of which everybody was afraid. But apart from the havoc which such catastrophic floods caused after great lengths of time, moderate floods as took place regularly were nothing but beneficial. They fertilised the soil, washed away malarial larvae. But when about 1850, the Government wanted to open the E.I.Ry. they determined to tame the Damodar in order that the railway might be safe. They shut up the river within watertight embankments, closed the headwaters of the various branches, and *made breaches by men in the embankments which were needed for irrigating their fields a criminal act.* The result was that though a safe highway for communication with upper India was opened and trade of Calcutta increased enormously, and people from the upcountry began to flood Calcutta in search of employment or adventure, it was done at a terrible cost to the people of the Burdwan Division. Two years after the opening of the railway in 1859, a terrible malarial epidemic broke out, and in Hugli alone, half the population, viz., one million out of two died within 10 years. The density of population fell from 750 per sq. mile to 500, and according to Bentley, and other com-

petent authorities who ascribe the outbreak of these terrible epidemic to the faulty system of railway embankments, the country has never been free from malaria up to the present time. The fertility of the soil fell by about 50%, as the land was deprived of the riverborne silt. *If there be anything like justice in the world, the people of Burdwan are entitled to compensation from the parties concerned, for all these terrible inflictions on them. It may be given to them, by imposing a terminal or thoroughfare tax on the railway passengers, and utilising the sum so collected to resuscitation of the old prosperity of the country by undertaking new constructive works according to well-laid-out and well-studied plans.* Part of the money may be spent in financing the proposed hydraulic research laboratory.

Let nobody think that when I am proposing that the people of Burdwan are entitled to compensation for the damage done to them, I am at all joking. Such a claim is supported by many engineers; Sir John Benton (in course of the discussion on the Sarah Bridge) says about a proposal to build railway bunds in N. Bengal for the safety of the Sarah Bridge:

"Any blocking of flood waters by these proposed new railway lines would increase the damage to crops, and in the light of experience of similar works elsewhere, this would lead to demand on the part of cultivators for compensation, or for increased waterway to pass the flood waters. The best efforts of the Railway Department would be devoted to show that the flood spills were not held up, and if these efforts failed, the railway authorities would have to provide increased waterway."

Against Benton's advice, the Railway authorities in N. Bengal built Railways with insufficient waterways. These are responsible for devastating floods and outbreak of malaria in North Bengal as well as for a fall in the fertility of the soil. Would the Government be prepared to give compensation to the inhabitants affected or be courageous enough to force the Railway authorities to provide for increased waterways?

Sufficient studies have not been made to show that on the Damodar "the five satanic chains" of Sir William Wilcocks

are absolutely necessary for the protection of the railways. Wilcocks has given his own scheme, which consists in providing increased spillway, and clearing the heads of the numerous branches. He estimates that this will double the productivity of 800,000 acres of land on the left bank of the Damodar. I am not in a position to examine this suggestion critically, but this suggestion should certainly be examined in all its bearings in the proposed laboratory. Catastrophic floods, the fear of which has led to extraordinary precautions against the Damodar, may be prevented by building storage basins in the Chotanagpur area at the points where the Damodar debouches from the hills.

Final Suggestion

My final suggestions are:

(*a*) Establishment of a Hydraulic Research Laboratory for study of the problems of River Training, Flood Irrigation, Navigation, and Waterpower development in Bengal.

This should be a purely Research Institute after the model of the Wasserbau Laboratory of Berlin-Charlottenburg or Vienna. The object should be the study of the physics of Great Rivers, preparation of plans in combination with department (b) and testing of the plan by means of laboratory models.

As the problems require expert knowledge of physics and mathematics, and demand much originality for their solutions, the laboratory should have a research atmosphere. It should be placed under a distinguished physicist who is also well up in mathematics. He should be provided with a good staff consisting of experts in allied lines, and a good laboratory.

Such a laboratory should be attached to the Universities, as Engineering Colleges in our country have not yet developed any research atmosphere. The initial expenses of a laboratory should not exceed Rs. 10 lakhs and the recurring expenditure 2 lakhs.

(*b*) Department for Field Service.

This will undertake a hydrographic survey of the rivers of Bengal, including relevant topics in Topography, Collection

of Precipitation Data (such work is being done on a small scale by Prof. P. C. Mahalanobis in the Presidency College), and other geophysical factors likely to be of use in the preparation of great constructive projects.

The department may be easily financed if my proposal of imposing a small thoroughfare tax on the passengers and trading parties utilising the E. I. Railway and E. B. Railway lines are accepted.

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"Samudra" in the Ṛg-Veda

By J. Przyluski (Paris).

The word "Samudra" has been interpreted in different ways. According to Max-Muller, it was generally used with the meaning of "ocean" but also with the meaning of "antarikṣa." Zimmer thinks that "samudra" denoted the river Indus after it had received all its Punjab tributaries. Hopkins follows Zimmer. B. Keith sees no clear sign that the Ṛg-Vedic Aryans had at that time reached the ocean (*Cambridge Hist. of India,* 1, 79). But the authors of the *Vedic Index* believe that a knoweldge of the ocean was "almost inevitable to people who knew the Indus" (*Vedic Index,* II, p. 432). In a recent contribution to the *Indian Historical Quarterly,* VII, 2, p. 353 sqq., M. Amiya Kumar Chakravarty has reviewed these conflicting opinions and added some new facts. I think that the solution of the problem is not to be found in any single verse of the Ṛg-Veda, but should rather be sought in a study of the ancient Aryan cosmology.

By people ignorant of exact geography, the sea may be conceived in two ways: (i) The inhabitants of islands or of sea-coasts believe that the sea is a boundless body of water from which the earth emerges like a fish or on which it rests like a boat. This is the maritime conception. (ii) The inhabitants of inland regions believe that the sea is a limited depositary of the waters of all the rivers which may be depicted as a great lake or as a huge river which flows down to an abyss or to the under-world. This is the continental conception.

A priori it is probable that the Ṛg-Vedic Aryans conceived a *Samudra* of the second type, while non-Aryan people living on the coast of India held maritime conceptions.

In fact, the most ancient Aryan cosmology is essentially con-

tinental. Outside the abode of men, there are two other abodes; that of the gods and that of the Fathers. The door of the first is in the north-east, that of the second in the south-east. There is a connection between these two abodes, the periods of the year and the course of the sun: Uttarāyana and Devāyana are contrasted with Dakṣiṇayāna and Pitṛyāna. Yama, the death-god and lord of the earth belongs to the south, the other gods to the north. Yama sits below; the other gods above. When a pit is dug, it is called the place of the Fathers. The path of the gods rises to heaven; the path of the Fathers is described as *Pravat*, which may denote "a downward path as of stream" (cf. Oldenberg, *Religion du Veda*, trans. V. Henry, p. 465; B. Keith, *Religion and Philosophy of the Veda*, p. 411; contra Pischel *Ved. Stud.*, II, p. 63 sqq). There is no place in this cosmology for a boundless ocean surrounding the earth. The rivers referred to by the word *Nadī* and its synonyms, flow down from the mountains to the region below. They go to the world of Yama, lord of the earth. According to this conception, *Samudra* may be only a huge depositary of water into which the various *Nadī* empty themselves. This *Samudra* was partly mythical, partly real. As a real notion, it may have denoted successively the great river Indus after it had received its Punjab tributaries, then the Arabian Sea when the Vedic Aryans had acquired a more exact knowledge of the country.

Quite different was the non-Aryan conception. The earth is surrounded by the sea. A continent is a great island. *Baru, Bharu, Maru* denote the boundless ocean and Varuṇa is the non-Aryan god of the sea (cf. *JRAS.*, 1931, p. 613 sqq). These ideas have survived in the myth of the four or seven *Dvīpa* and in the Buddhistic lore. "This great earth, Ānanda, is established on water, the water on wind, and the wind rests on space. And at such a time, Ānanda, as the mighty winds blow, the waters are shaken by the mighty winds as they blow, and by the moving water the earth is shaken. These are the first causes, proximate and remote, of the appearance of a mighty earthquake. Again, Ānanda, a Samaṇa or a Brāhman of great (intellectual) power, and who has the feelings of his heart well under his control, or a god

or fairy (*Devatā*) of great might and power, when such one by intense meditation of the finite idea of earth or the infinite idea of water (has succeeded in realising the comparative value of things) he can make the earth move and tremble and be shaken violently. These are the second causes, proximate and remote, of the appearance of a mighty earthquake" (*Mahāparinibbānasutta,* III, 14, 15, trans. Rhys Davids. cf. J. Przyluski, *Le Parinivāṇa et les Funérailles du Buddha,* p. 64).

When the Aryans came into contact with the people of the sea, the religion of the former was deeply influenced by the non-Aryan mythology. As there was no place in the ancient cosmology for a boundelss ocean, Varuṇa was introduced into the Aryan pantheon, but his realm remained outside Vedic geography. The sky became the Varuṇa's dwelling and the boundless ocean was identified with the atmosphere. The intermixing of two different mythologies may thus account for the various senses of *Samudra* in the Ṛg-Veda. According to Yāska, *Samudra* is a large depositary of water and may also denote the atmosphere, etc. In fact, in the Ṛg-Veda *Samudra* is sometimes a synonym of *Antarikṣa*. This is probably the result of the adaptation of a notion, foreign to the ancient Aryan cosmology.

Experimental Researches on Co-ordination

By Gilbert T. Morgan (Teddington).

Included in the purview of chemical philosophy is a consideration of the manifold manifestations of chemical affinity, that pervasive tendency which induces the combination of chemical elements to form an infinite variety of chemical compounds.

It is evident from a general survey of inorganic and organic substances that the numerous and varied generic types could scarcely have arisen as the effect of a simple causation or tendency for, even if there be a unity of natural forces of which chemical affinity is but one manifestation, the facts of chemical science compel us to assume considerable variation in the circumstances under which such an affinity operates.

In the present paper the writer has given a summary of his experimental researches on residual affinity and co-ordination which have been carried out in collaboration with many chemical friends during the last twenty five years.

I. Oxonium Salts of Coumarin

Coumarin, the odoriferous principle of woodruff, Tonquin bean and many other plants, although but sparingly soluble in cold water dissolves readily in concentrated hydrochloric or hydrobromic acid and from the latter solvent Ebert formerly isolated an unstable addition compound (*Annalen*, 1884, **226** 347). In 1906 the writer added a strong solution of chloroplatinic acid to coumarin dissolved in concentrated hydrochloric acid, when there slowly separated a well defined yellow crystalline substance which was examined further in collaboration with Miss F. M. G. Micklethwait. The product had the composition of a hydrated coumarin platinichloride $4C_9H_6O_2,H_2PtCl_6,4H_2O$. Other compounds of

similar type were then discovered such as the aurichloride $4C_9H_6O_2,HAuCl_4,4H_2O$, the cobalticyanide $3C_9H_6O_2,H_3Co(CN)_6,3H_2O$ and the hydriodide periodide $4C_9H_6O_2HI,I_3$. These results bring coumarin into line with other oxygenated substances such as pyrone which yields $4C_5H_4O_2,H_2PtCl_6$ (Werner. *Annalen*, 1902, **322**, 312), dimethylpyrone which furnishes $2C_7H_8O_2,H_2PtCl_6$ (Collie and Tickle, *Trans. Chem. Soc.*, 1899, **75**, 712) and the trialkylphosphine oxides which give rise to platinichlorides $4X_3PO,H_2PtCl_6$, where $X = CH_3$, C_2H_5 or C_7H_7 and 6 $(C_3H_7)_3PO,H_2PtCl_6$ (Letts and Collie, *Trans. Chem. Soc. Edin.*, 1880, **30**, [i], 181; and Pickard and Kenyon, *Trans. Chem. Soc.*, 1906, **89**, 268).

At the time of these discoveries the foregoing substances were grouped either as "molecular compounds" or as oxonium salts arising from the tendency possessed by oxidic oxygen of assuming a valency higher than that of a diad element. But it was evident from the composition of the products that this effect could not be indicated precisely in terms of any theory of integral valency (Morgan and Micklethwait, *Trans. Chem. Soc.*, 1906, **89**, 863). A clearer conception of the tendency underlying the formation of these oxonium compounds involves a recognition of the co-ordination link (Sidgwick, *Trans. Chem. Soc.*, 1923, **123**, 725) by virtue of which oxygen already bound by two non-polar covalent links can still supply two pairs of lone electrons to co-ordinate with such electron acceptors as the hydrion or the metallic ions.

II. Twofold Associating Units

The early years of the present century witnessed the establishment by Alfred Werner of the co-ordination theory of valency and chemical constitution which he first propounded in 1891 devoting subsequently twenty years of his life to the accumulation of experimental evidence for his view on the nature of valency. These ideas were at first largely disregarded by his contemporaries until Werner's successful verification of his prediction of a new type of optically active salts containing co-ordinated cobalt compelled acceptance of his hypotheses. This discovery which

constituted an important development in stereochemistry was speedily generalised by Werner's subsequent discoveries of optically active compounds of octahedral symmetry containing chromium, iron, iridium, platinum, rhodium and ruthenium. These striking confirmations of Werner's conception gave to the co-ordination principle the essential attributes of a scientific theory of fundamental importance.

Considerable ingenuity was displayed in the selection of co-ordination compounds suitable for resolution into optical enantiomerides and important use was made of twofold associating units which are compounds or compound radicals capable of occupying two positions in a co-ordination complex. Thus each ammonia occupies one position in the luteocobalt chloride $[Co6NH_3]Cl_3$, whereas each ethylenediamine (en) molecule in similar circumstances, $[Co3en]Cl_3$, occupies two positions. Similarly each cyanogen radical takes one position in the cobalticyanide $K_3[Co(CN)_6]$, whereas each oxalato-group fills two positions in the double oxalate $K_3[Co(C_2O_4)_3]$. This complex oxalate and the trisethylenediaminocobaltic chloride are racemoid compounds which were resolved by Werner into optically active components, thereby confirming the octahedral symmetry of the two corresponding sets of cobalt co-ordination compounds. *Chelate Groups.* For compounds and compound radicals which can function in co-ordination complexes as twofold associating units the writer has suggested the short convenient name of chelate groups from χ η λ η′ (Greek), chela (Latin) and chely (English) —the crab's pincer (*Trans. Chem. Soc.*, 1920, **117**, 1457).

Metallic Acetylacetones

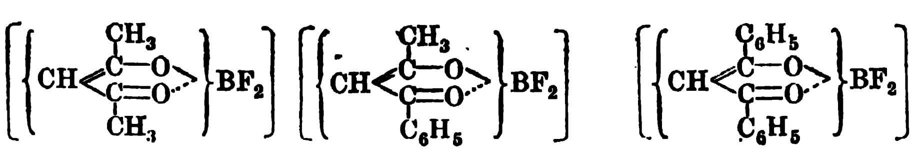
A notable example of a chelate group is furnished by the univalent radical of acetylacetone $CH_2(COCH_3)_2$ which enters into combination with the majority of metallic and metalloidal elements and even with certain non-metals. The acetylacetones of univalent metals are generally decomposed on heating but those of bi-and tri-valent metals have remarkable stability and in certain instances may be distilled without decomposition.

Scandium acetylacetone begins to sublime at 157° and distils at its melting point (187°) under 8-10 mm. pressure (Morgan and H. W. Moss, *Trans. Chem. Soc.*, 1914, **105**, 197). Gallium acetylacetone prepared in collaboration with Dr. H. D. K. Drew (*loc. cit.*, 1921, **119**, 1060) sublimes at 140° under 10 mm. pressure. The late Dr. T. V. Barker, who undertook the crystallographic examination of this preparation, showed that the five acetylacetones of aluminium, gallium, indium, iron and scandium are members of an isotrimorphous series. (Compare W. T. Astbury, *Proc. Roy. Soc.*, 1926, A**112**, 448).

Vanadium yields a brown trisacetylacetone VAc_3 (co-ordination number 6) distillable in small quantities but oxidising readily in moist air to green vanadyl bisacetylacetone $VOAc_2$ with an odd co-ordination number 5 (Morgan and Moss, *Trans. Chem. Soc.*, 1913, **103**, 86).

Reference should be made to the interesting polar compounds produced by the interaction of boron trichloride and acetylacetone (Dilthey, *Annalen*, 1905, **344**, 300; *Ber.*, 1903, **36**, 923, 1595, 3207; and Rosenheim, Loewenstamm and Singer; *ibid.*, 1834). A bisacetylacetone boronium chloride is produced which gives rise to comparatively stable double salts such as $[BAc_2]AuCl_4$ or $FeCl_4$ and $[BAc_2]_2PtCl_6$. Analogous siliconium salts were described by the foregoing investigators as follows:— $[SiAc_3]AuCl_4$ or $FeCl_4$, or $[SiAc_3]_2PtCl_6$.

Different phenomena are observed with the non-metallic chlorides replaced by fluorides. Silicon tetrafluoride is entirely inert towards β-diketones, whereas boron trifluoride reacts energetically with these organic reagents, heat being generated. One fluorine radical is replaced by a β-ketonic chelate group having the structure denoted by the following formulae:—



(Morgan and Tunstall, *Trans. Chem. Soc.*, 1924, **125**, 1964; compare Sugden, *Journ. Chem. Soc.*, 1932, 1494).

The elements of periodic group four, from silicon onwards, have all been combined with the acetylacetone radical Ac; the products vary somewhat in type as is indicated in the following diagrams :—

$[SiAc_3]AuCl_4$.	$[GeAc_3]CuX_2$		
	$[GeAc_2X_2]$	$[SnAc_2X_2]$	$PbAc_2$.
$[TiAc_3]FeCl_4$	$[ZrAc_3]Cl$.	$CeAc_3$	
	$ZrAc_4$	$CeAc_4$	$ThAc_4$.

(Morgan and Drew, *Trans. Chem. Soc.*, 1924, **125**, 1263; and Morgan and Bowen, *loc. cit.*, 1254).

The cerium, thorium and zirconium compounds of general formula RAc_4 are of interest as suggesting an eight point system but at present there is no experimental evidence that this corresponds with a cubical arrangement of the chelate groups about the central metallic atom.

Zirconium tetra-acetylacetone is to be regarded as a limiting case, for this metal also gives rise to polar compounds with the β-diketones as exemplified below in the cases of dibenzoylmethane, benzoylacetone and acetylacetone.

$$\left[Zr\left(<\begin{smallmatrix}O\cdot C(C_6H_5)\\ O{:}C(C_6H_5)\end{smallmatrix}>CH\right)_3\right]Cl \rightarrow \left[Zr\left(<\begin{smallmatrix}O\cdot CPh\\ O{:}CPh\end{smallmatrix}>CH\right)_3\right]_2[PtCl_6]$$

$$\searrow$$

$$\left[Zr\left(<\begin{smallmatrix}O\cdot CPh\\ O{:}CPh\end{smallmatrix}>CH\right)_3\right][FeCl_4] \text{ or } [AuCl_4]$$

$$Zr\left(<\begin{smallmatrix}O\cdot C(C_6H_5)\\ O{:}C(CH_3)\end{smallmatrix}>CH\right)_3\Big]Cl \quad \left[Zr\left(<\begin{smallmatrix}O\cdot C(CH_3)\\ O{:}C(CH_3)\end{smallmatrix}>CH\right)_3\right]Cl$$

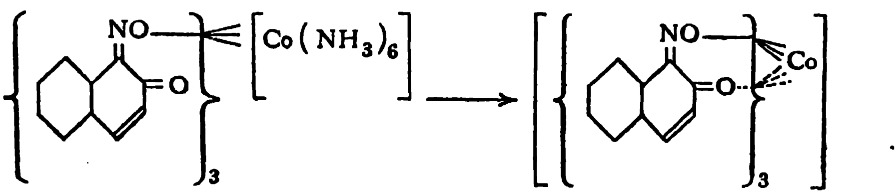
III. Lakes of Mordant Dyes as Internal Metallic Complexes

The close analogy between the metallic derivatives of β-diketones and the lakes of mordant dyes was a a matter which greatly interested Werner who expounded the view that mordant lakes are internal metallic complexes. Since his death this view has been tested experimentally by Dr. J. D. Main Smith and the writer on representative mordant dyes and it has been shown that any acidic substance capable of forming a colour lake must contain a chelate group capable of combining co-ordinatively with

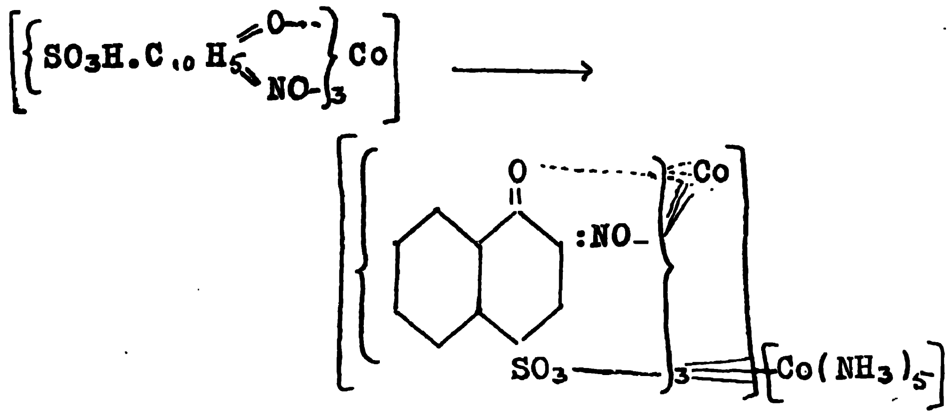
the metallic mordant. In every case examined the resulting lake has proved to be an internal metallic complex.

A few typical examples will serve to indicate the way in which this point has been demonstrated experimentally.

The cobaltammine reagent generally employed was hydroxopentamminecobaltic chloride $[HO.Co5NH_3]Cl_2,H_2O$ (Werner, *Ber.*, 1907, **40**, 4098) but the roseo- and luteo-cobaltammine salts $[H_2OCo5NH_3]Cl_3$ and $[Co6NH_3]Cl_3$ were also used occasionally. Nitroso-β-naphthol (1 : 2-naphthaquinone-1-oxime) known to dyers as "Gambine Y" is generally applied to textiles in conjunction with iron or chromium mordants. It also gives rise to an insoluble red cobaltic derivative employed analytically in the separation of cobalt from nickel and other metals. When the green sodium derivative of this dye interacts with luteocobaltic chloride at the ordinary temperature a sparingly soluble green hexamminocobaltic 1 : 2-naphthaquinone-1-oximate is precipitated, which on warming to 40° loses all its ammonia and passes quantitatively into the red cobaltic lake.

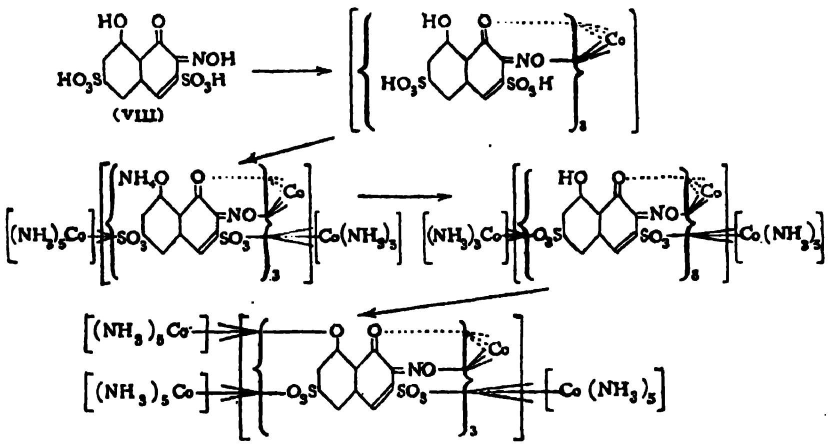


Whenever the mordant dye contains another acid group besides the one forming part of the chelate radical as in the case of "Naphthol Green G", its complex lake with the cobaltammine reagent contains two cobalt atoms, one of which retains the property of co-ordinating with the ammonia as in the purpureo ammines $[XCo5NH_3]X_2$



In the graphic formulae for the complex lakes it should be understood that one acidic (oxy, CO_2 or SO_3) group out of three is implicated in the pentamminocobaltic co-ordination sphere, giving a co-ordination number of six. This relationship is represented conventionally by carrying one linking out of three into the co-ordination sphere.

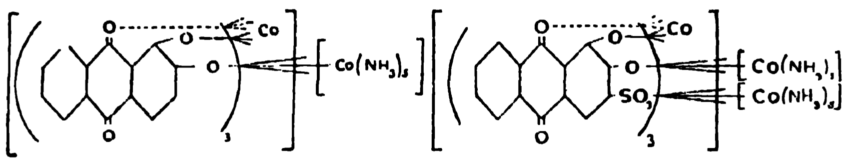
If the complexity of the cobalt lake is increased by the inclusion of more acidic groups as in nitroso-H-acid (VIII), then the three acidic groups (one hydroxyl and two sulphonic raidcals) retain the property of forming cobaltammine salts, whereas the chelate group completely satisfies the residual affinity of the implicated cobalt atom.



In this increasingly complex series of cobaltic lakes there is a constant ratio between the number *n* of cobalt atoms and the

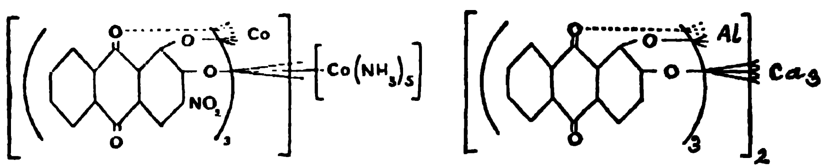
number m of ammonia molecules indicated by the equation $m = 5(n - 1)$. This simple relationship indicates that there is one cobalt atom which is not capable of co-ordinating with ammonia as in $K_3[Co(C_2O_4)_3]$ and many similar compounds. Hence each lake-producing group O:C-C:NOH of the foregoing dyes is equivalent to the oxalate radical and is accordingly to be regarded as a chelate group (*Trans. Chem. Soc.*, 1921, **119**, 707).

Similar relationships are revealed among the members of the alizarin series of dyes (*Trans. Chem. Soc.*, 1922, **121**, 161). When tested by the cobaltammine reagent Alizarin Red shows the properties of a monochelate dye with one subsidiary acid group (I). Alizarin Red S, its sulphonic acid, contains two subsidiary acid groups and the complex cobaltammine lakes correspond with the following formulae I and II :—



I II

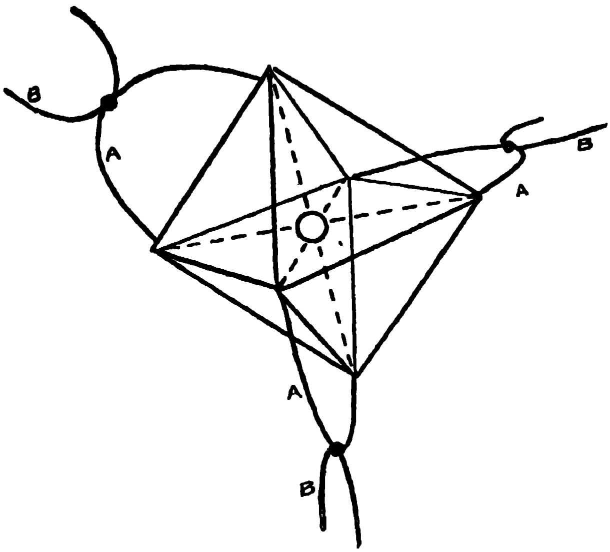
Formula III shows the corresponding lake from nitroalizarin (Alizarin Orange) and formula IV indicates the ordinary Turkey Red dye on wool in which tervalent cobalt is replaced by aluminium and the subsidiary hydroxyl radical satisfied by calcium.



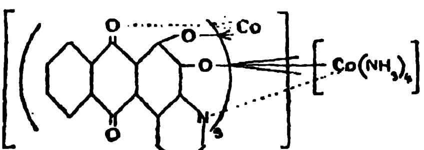
III IV

Alizarin Blue affords an example of a dichelate mordant dye the second chelate radical including the hydroxyl of position 2 and the quinoline nitrogen of position 3. If the first chelate group A is thrice co-ordinated at the vertices of one octahedral cobalt atom as shown in the following diagram, then of the three wide-spread second chelate groups B only one could co-ordinate with the second

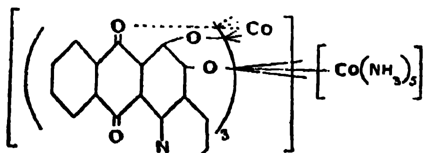
cobalt atom occupying two positions out of six, leaving four available for co-ordination with ammonia.



Alizarin Blue (Alizarin-3-quinoline) is an example of a dichelate dye and its cobaltic lake has the composition expressed by formula V, but when the quinoline ring is inverted so that the nitrogen is in the more remote position 4 as in Alizarin Green M. L. & B. a second chelate group is no longer present and the cobaltic lake has a composition corresponding with formula VI.



V

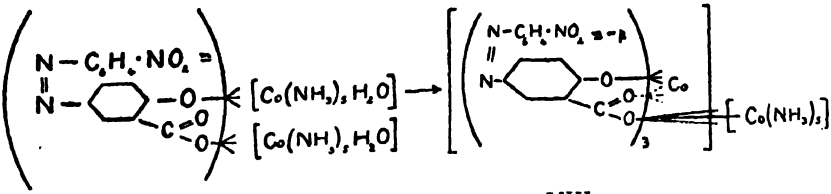


VI

With such dichelate dyes the relation between ammonia molecules m, cobalt atoms n and chelate groups C is summarised by the equation $m = 5\left\{n - \frac{C+4}{5}\right\}$. When C is unity in the simpler case of monochelate dyes the equation reverts to the original form $m = 5(n-1)$.

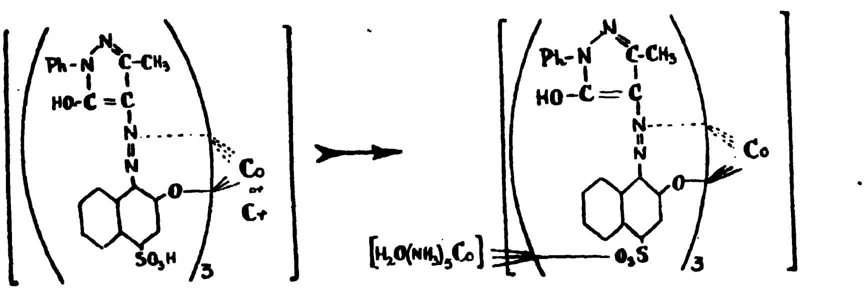
Although substantive for wool, the azosalicylic acid dyes are generally applied in conjunction with chrome mordant giving various shades of khaki yellow.

Alizarin Yellow GG and Alizarin Yellow R behave similarly to Gambine Y when treated with roseocobaltic chloride. They react in two stages the first formed diroseo salt (VII) losing half its ammonia and passing into the chelated lake (VIII).



VII VIII

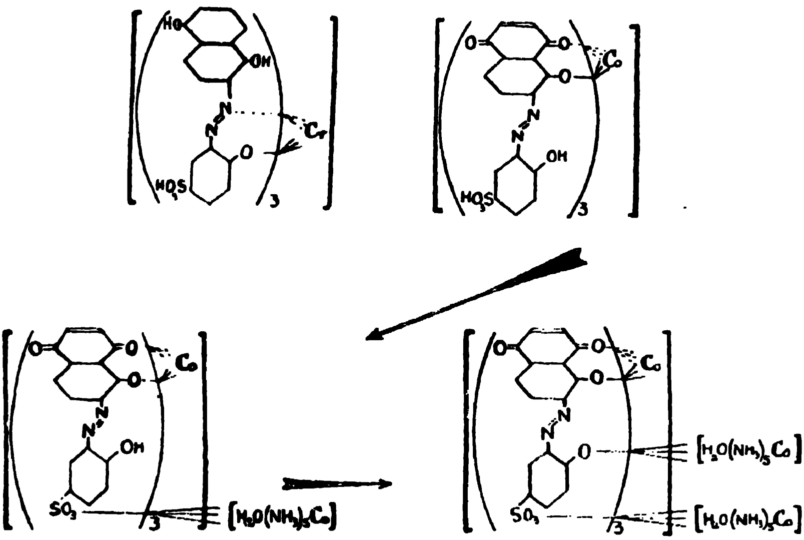
Two cases may be distinguished in the formation of colour lakes from hydroxyazo dyes (a) those in which the lake is an insoluble salt of the original azo compound and (b) those where the lake is only fully developed as the result of oxidation of the original dyestuff. Eriochrome Red B is a typical example of the former case; it gives a cobaltic or chromic lake (IX) corresponding with the original dye.



IX

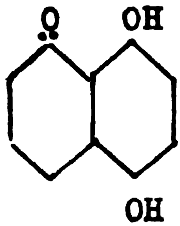
Diamond Black PV $SO_3H.C_6H_3(OH).N_2.C_{10}H_5(OH)_2$ from diazotised o-aminophenol-4-sulphonic acid and 1 : 5-dihydroxy-naphthalene presents the more complicated case of a dyestuff which does not give the full black shade with chromic fluoride (X) but only with chromic acid. Oxidation of this azo dye occurs also with roseocobaltic chloride giving a simple cobaltic lake (XI) of oxidised Diamond Black corresponding with the black lake obtained in practice on the fibre with the dye and chromic acid. Further treatment with the roseocobaltammine leads to complex mono- and di-roseo salts (XII and XIII).

X XI

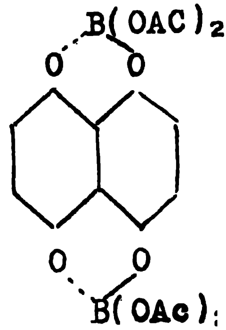


XII XIII

The foregoing examples serve to show that a study of co-ordination complexes often throws light on the nature of the colour lakes of natural and synthetic colouring matters. Reference should be made to an ingenious application of co-ordination principles to the revision of the constitution of naphthazarin (Alizarin Black), a colour principle which had long been regarded as a naphthalenoid analogue of alizarin. For this purpose Dimroth and Ruck (*Annalen,* 1925, **446**, 123) used pyroboric acetate $(CH_3CO.O)_2BOB(O.COCH_3)_2$, a reagent which with alizarin in acetic anhydride yielded a monoboric ester, but with naphthazarin and quinizarin gave rise to a diboric ester (XV) thus indicating that napthazarin is really 5:8-dihydroxy-1:4-naphthaquinone (XIV).



XIV

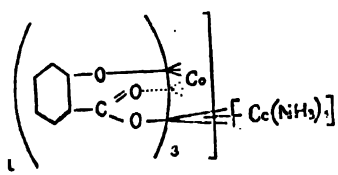


XV

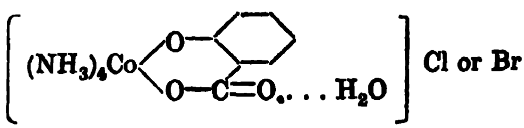
Pfeiffer confirmed this result by the use of stannic chloride in benzene when alizarin behaved as a monochelate compound, whereas naphthazarin and quinizarin showed the reaction of dichelate derivatives (*Ber.*, 1927, **60**, 1111).

IV. Subsidiary Foci of Co-ordination

Salicylic acid itself resembles its azo-derivatives furnishing an insoluble lake (XVI) with the cobaltammine reagent $[HO.Co5NH_3]Cl_2$, but by a suitable modification of experimental conditions this green lake bcomes almost entirely replaced by well defined crystalline salicylatotetramminocobaltic chloride or bromide (XVII), a salt containing a new type of cobaltammine complex in which the bivalent salicylate radical is implicated as a chelate group (Morgan and Main Smith, *Trans. Chem. Soc.*, 1922, **121**, 1956; 1923 **123**, 1096).



XVI

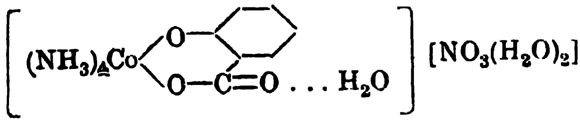


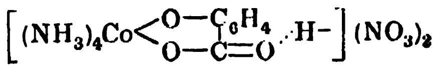
XVII

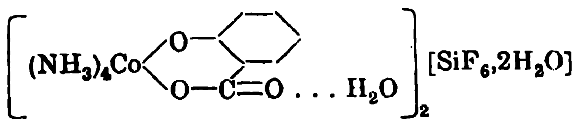
This new cobaltammine complex has given rise to two long series of well crystallised salts which exhibit several points of interest :—

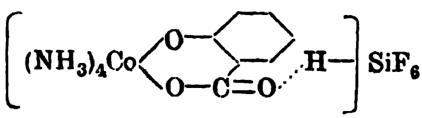
(*i*) The salicylatotetramminocobaltic complex simulates the behaviour of the sodium ion in regard to the solubility of its salts in water. Acidic radicals which serve as precipitants for the sodium ion give rise to sparingly soluble salicylatotetramminocobaltic salts, such as pyroantimonate, bicarbonate, dihydroxytartrate, mesoxalate, α-napthylamine-8-sulphonate and the acid and normal oxalates.

(*ii*) In its normal salts this cobaltammine radical exists in a hydrated form, but it shows a marked tendency to form acid or hydrogen salts in which it exists in an anhydrous condition. These alternative conditions are illustrated by the cases of the nitrates and the silicofluorides.

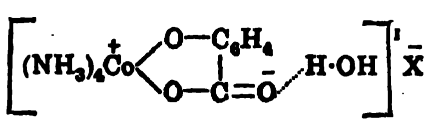


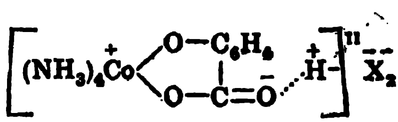






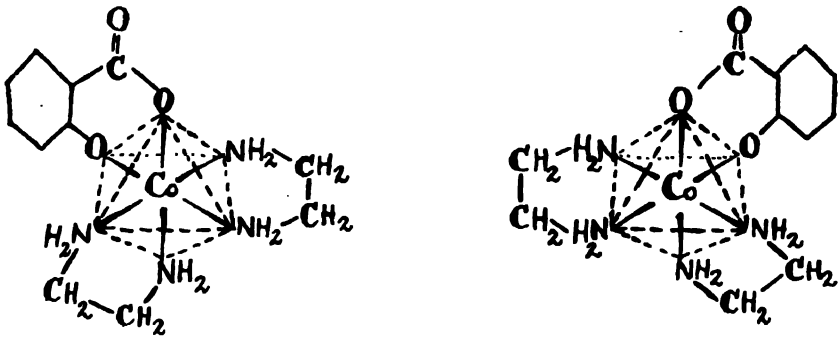
These characteristics of the salicylatotetramminocobalt complex are explained by assuming that it contains two foci of co-ordination, a positive focus due to the tervalent cobalt atom and a negative focus attributable to an oxygen atom and probably to that oxygen which is present in the carbonyl radical.





The constitution ascribed to the salicylatotetramminocobalt complex is confirmed by replacing the four ammonia molecules

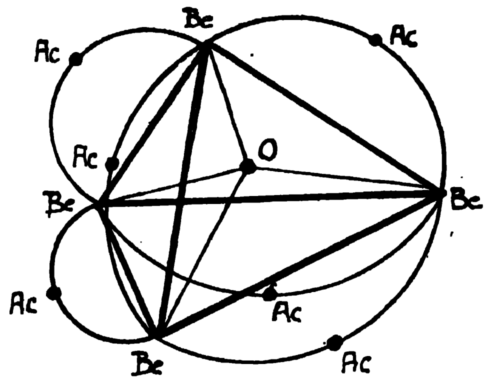
by two ethylenediamines when a racemoid complex results, which has been resolved successfully by the aid of *d*- and *l*-camphorsulphonic acids into optically active enantiomerides (Morgan and Main Smith, *Trans. Chem. Soc.*, 1924, **125**, 1998).



V. *Polynuclear Co-ordination*

In the foregoing examples the co-ordination compounds exhibit a centralised structure with one nuclear metallic element surrounded by radiating associated units. The case of basic beryllium acetate and its homologues investigated in collaboration with Sir William Bragg and Mr. W. T. Astbury illustrates another type of co-ordination complex which contains four metallic atoms (*Proc. Roy. Soc.*, 1923, **A. 104**, 437 and 1926, **A**, **112**, 448).

Analysis by X-rays of the basic beryllium acetate $OBe_4(CO_2.CH_3)_6$ confirmed the stereochemical conception of the chemical constitution of this non-ionised compound, which has the unitary structure of a typical organic compound. The unique oxygen atom is situated at the centre of a tetrahedron, the four beryllium atoms are arranged on lines joining the centre with the four vertices of this regular solid, whereas the six acetate groups (Ac) are distributed symmetrically about the six sides of the tetrahedron.

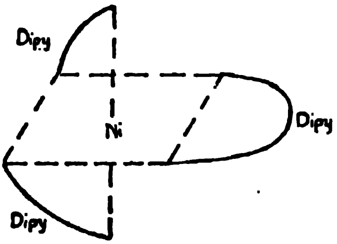


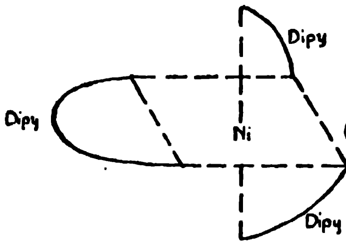
The crystals of basic beryllium acetate display cubic symmetry and it must accordingly be assumed that this crystal structure is not modified appreciably by the sixteen hydrogen atoms which cannot all be symmetrically distributed with respect to either the vertices or the edges of the tetrahedron. But when one hydrogen of the methyl groups is replaced by a methyl radical as in basic beryllium propionate, $OBe_4(CO_2.CH_2.CH_3)_6$, the symmetry of the crystal is diminished and this basic salt belongs to the monoclinic isobutyrate, $OBe_4[CO_2.CH(CH_3)_2]_6$, but is restored in basic beryllium pivalate, in which the three hydrogen atoms of the methyl group have been replaced by three methyl groups giving OBe_4-$[CO_2.C(CH_3)_3]_6$.

VI. Manifold Associating Units

Reference has already been made to twofold associating units or chelate groups and their effect in producing stable complexes generally characterised by co-ordination numbers of 4, 6 or 8. Among the most noteworthy of these chelate groupings is the one supplied by $\alpha\alpha'$-dipyridyl (dipy), for it was by means of this diamine that Werner (*Ber.*, 1912, **45**, 433) resolved into optically active forms the tris-$\alpha\alpha'$-dipyridylferrous bromide [Fe3dipy]-Br_2,$6H_2O$ previously prepared by Blau (*Monatsh.*, 1898, **19**, 647). The latter observer had also described analogous nickel salts. In collaboration with Mr. Burstall the hexahydrated tris-$\alpha\alpha'$-

dipyridylnickelous chloride $[Ni3dipy]Cl_2,6H_20$ has recently been resolved into optically active enantiomorphous forms using for this purpose ammonium *d*- and *l*-tartrates (*Journ. Chem. Soc.*, 1931, 2214).

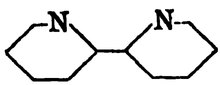
(I.)




(II.)

$\alpha\alpha'$-Dipyridyl has served a further useful purpose; it has served to stabilise the bivalent condition of silver. The earliest observations on bivalent silver salts were made by Barbieri, who first obtained tetrapyridinoargentic persulphate and subsequently the corresponding nitrate:—$[Ag4py]S_2O_8$ or $(NO_3)_2$ (*Gazzetta*, 1912· **42**, ii, 7 and *Ber.*, 1927, **60**, 4224). More recently Hieber and Muehlbauer (*Ber.*, 1928, **61**, 2149) have prepared a series of complex argentic salts $[Ag2phenan]S_2O_8$ or X_2 using α-phenanthroline as co-ordinating diamine.

In the Teddington Laboratory (Morgan and Burstall, *J. Chem. Soc.*, 1930, 2594) two types of argentic salts (IV and V) have been isolated with two and three molecular proportions of $\alpha\alpha'$-dipyridyl. (co-ordination numbers 4 and 6) as indicated in the following diagram where I and II are the starting materials $\alpha\alpha'$-dipyridyl and its compound with argentous nitrate.



(I.)

$[Ag2dipy]^{I}NO_3$
(II.)

$[Ag2dipy]^{II}S_2O_8$
(III.)

$[Ag3dipy]^{II}(NO_3)_2,(ClO_3)_2$ or $(ClO_4)_2$.
(IV.)

$[Ag2dipy]^{II}(HSO_4)_2$
(V.)

Professor Sugden, who has examined these complex salts of bivalent silver in comparison with ordinary argentous salts, has shown that the bivalent silver derivatives are paramagnetic whereas the argentous compounds are diamagnetic (*J. Chem. Soc.*, 1932, 161). This observation brings these two series into line with cupric and cuprous compounds for in this case the bivalent

copper derivatives are paramagnetic and those of univalent copper are diamagnetic.

The Cupric Condition stabilised by Ethylenediamine

Cupric salts of the less electronegative ions are unstable and pass spontaneously into cuprous compounds, as for example the iodide, cyanide, nitrite, sulphite, thiosulphate, thiocyanate and selenocyanate. But in such instances the cupric condition can be stabilised by co-ordination with ethylenediamine and this aspect of the subject has been examined by Mr. Burstall and the writer.

The iodide has been fully stabilised and the cyanide partially stabilised as follows:—

$$[\mathrm{Cu,2en,2H_2O}]\,\mathrm{I_2} \rightleftharpoons [\mathrm{Cu,2en,R.OH}]\,\mathrm{I_2}$$

$$\mathrm{R.OH} = \mathrm{H_2O,\ CH_3OH\ or\ C_2H_5OH.}$$

$$[\overset{\mathrm{II}}{\mathrm{Cu}},\mathrm{2en}]\,[\overset{\mathrm{I}}{\mathrm{Cu}}_2(\mathrm{CN})_3]_2 \qquad 1 : 4$$

$$[\overset{\mathrm{II}}{\mathrm{Cu}},\mathrm{2en,H_2O}]\,[\overset{\mathrm{I}}{\mathrm{Cu}}(\mathrm{CN})_2]_2 \qquad 1 : 2$$

$$[\mathrm{en},\overset{\mathrm{II}}{\mathrm{Cu}}..\mathrm{H_2O}..\overset{\mathrm{II}}{\mathrm{Cu}},\mathrm{en}]\,[\overset{\mathrm{I}}{\mathrm{Cu}}(\mathrm{CN})_3]_2 \qquad 1 : 1$$

Ten other unstable cupric salts have been combined with ethylenediamine and it is significant that in all these cases the complex contains two molecular proportions of ethylenediamine, and moreover nine of these salts are anhydrous. The consensus of evidence is in favour of the acquired co-ordination number 4 as representing the most favoured configuration:—

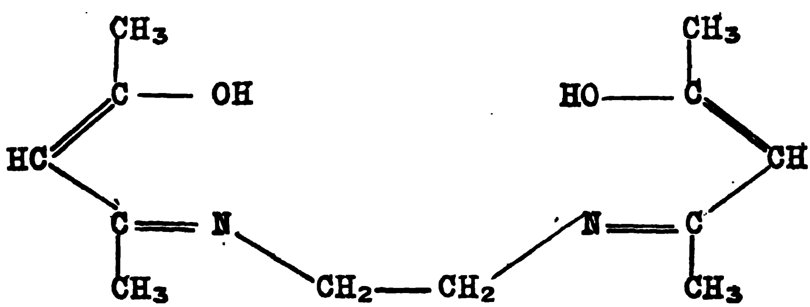
$[\mathrm{Cu,2en}]\mathrm{X'_2}$	$[\mathrm{Cu,2en}]\mathrm{X''}$
$[\mathrm{Cu,2en}](\mathrm{NO_2})_2$	$[\mathrm{Cu,2en}]\mathrm{CO_3,\ 2H_2O}$
$[\mathrm{Cu,2en}](\mathrm{H_2PO_2})_2$	$[\mathrm{Cu,2en}]\mathrm{SO_3}$
$[\mathrm{Cu,2en}](\mathrm{CNSe})_2$	$[\mathrm{Cu,2en}]\mathrm{S_2O_3}$
	$[\mathrm{Cu,2en}]\mathrm{S_2O_6}$
	$[\mathrm{Cu,2en}]\mathrm{S_3O_6}$
	$[\mathrm{Cu,2en}]\mathrm{S_4O_6}$
	$[\mathrm{Cu,2en}]\mathrm{S_2O_8}$

The discovery by Mills and Gotts (*J. Chem. Soc.*, 1926, 3121) of optical activity among copper compounds having a co-ordination number 4 affords direct proof of tetrahedral arrangement. In the case of the cupric ion this co-ordination number 4 offers the optimum condition as regards symmetrical arrangement of associating units coupled with a very close approximation to the saturated electronic structure of krypton.

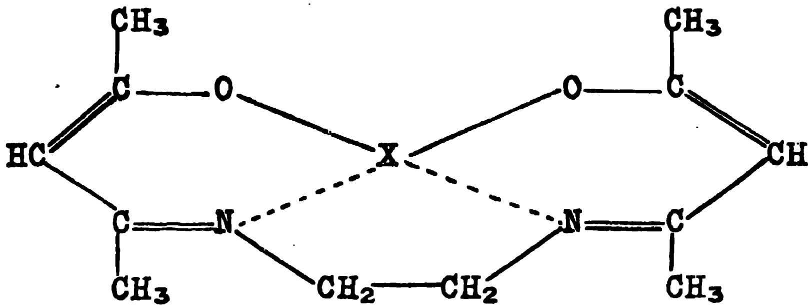
Tridentate Groups. A threefold associating unit has been found in $\alpha\beta\gamma$-triaminopropane (tpn) by Pope and Mann which co-ordinates with cobalt and rhodium as a tridentate radical to furnish the complex salts [Co2tpn]Cl_2 and [Rh2tpn]I_2 (*Proc. Roy. Soc.*, 1925, **107**, 20).

More recently Mr. Burstall and the writer have obtained a tripyridyl (bis-2 :2[1]-dipyridyl-2 :6-pyridine) (tripy), which forms complex ferrous and nickelous salts, [Fe2tripy]Br_2, $1\frac{1}{2}H_2O$ and [Ni2tripy]Br_2,$3H_2O$, the latter existing in two forms (*J. Chem. Soc.*, 1932, 22). With platinous chloride this triamine co-ordinates to form soluble deep red cyrstalline salts, [NH_3Pttripy]Cl_2 and [PyPttripy]Cl_2, in which the fourth position in the co-ordination complex is filled by ammonia and by pyridine respectively.

Quadridentate Groups. A fourfold associating unit or quadridentate group is furnished by the bivalent radical (ec) of ethylenebisacetylacetone,



which forms remarkably stable complex with copper, nickel and palladium (bivalent metal = X)



X = Co, Ni or Cu

In absence of air the copper and nickel compounds may be boiled without decomposition. Cobaltic complex salts [Co.ec2NH_3]Br may exist in stereoisomeric forms (Morgan and Main Smith, *Trans. Chem. Soc.*, 1925, **127**, 2033 and 1926, 912).

The β-aminotriethylamine $N(CH_2.CH_2.NH_2)_3$ = tren also behaves as a fourfold associating unit and gives rise to platinum salts [Pt tren]I_2 and [$PtCl_2$ tren]Cl_2(Mann and Pope, *Proc. Roy. Soc.*, 1925, **109**, 455) and to the cobaltic derivatives [$(SCN)_2$ Co-tren]SCN, H_2O (Mann, *J. Chem. Soc.*, 1929, 409).

VII. Co-ordination Numbers—Natural and Acquired

Two factors are discernible in processes of co-ordination round a central metallic ion.

The first factor is the tendency for the metallic ion to take up electrons so as to acquire by co-ordination the stable electronic structure of the next higher gas. In Dr. Sidgwick's words "the effect of chemical combination is to approach this symmetry either by sharing electrons so that they count for both atoms (non-polar linking, co-valency) or through electrons passing on from one atom to another (polar linking, electrovalency)." [*Trans. Chem. Soc.*, 1923, **123**, 726.]

In brief, this factor represents an attempt at self-expression and if this factor predominated, each element would have its own natural co-ordination number depending on several circumstances

peculiar to each element, such as its position in the periodic arrangement, its valency and its atomic volume.

The second factor, which depends on circumstances external to the atom, arises from the conditions in which the co-ordination complex is brought into being. A positively charged metallic ion attracts negatively charged associating units which at the same time repel each other with the result that they tend to arrange themselves symmetrically round the sphere of influence of the central atom thus giving rise to fourfold, sixfold or possibly eightfold arrangements corresponding respectively to the tetrahedron, octahedron or cube.

This tendency towards a symmetry external to the atom frequently acts in opposition to the factor of self-expression, so that in the majority of cases the metal acquires one or other of the co-ordination numbers due to the external forces.

The existence of the very large number of cobaltammines and allied substances arises from the circumstance that in the case of the tervalent cobalt ion the internal and external tendencies act in conjunction.

A similar agreement of internal and external tendencies exists in the case of the quadrivalent platinum ion and accounts for the many well-defined platinammines and complex salts (platinichlorides etc.)

Owing to the existence of optically active enantiomerides there can be little doubt that the sixfold co-ordinated compounds of quadrivalent platinum have an octahedral symmtery. There is, however, still room for controversy in regard to the spatial configuration of the complex compounds of bivalent platinum. Here the co-ordination number is generally four and the question arises whether the associating units are arranged tetrahedrally or in coplanar fashion at the corners of a rectangle. Recent investigations by Drew, Pinkard, Wardlaw and Cox (*J. Chem. Soc.*, 1932, 988, 1004) suggest that one of these arrangements does not exclude the other, for these authors recognise three isomeric diamminoplatinous dichlorides or one more than the number demanded by the theory of *cis* and *trans* isomerism. An X-ray

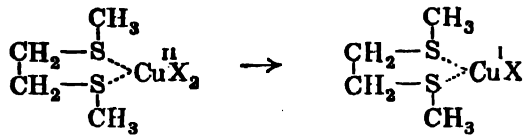
examination of tetramminoplatinous dichloride monohydrate supports the view that the four ammonia molecules are coplanar (Cox, *J. Chem. Soc.*, 1932, 1912). In these compounds of bivalent platinum, ammonia and pyridine may be replaced by dialkyl sulphides, trialkylphosphines and trialkylarsines. Isomeric pairs of compounds have been isolated in these cases and by analogy rather than by direct experimental evidence these isomerides are regarded as having a *cis* and *trans* configuration.

An investigation made in conjunction with Dr. V. E. Yarsley on the interaction of trimethylstibine and chloroplatinic acid led to the isolation of two compounds of identical percentage composition, one being a soluble yellow monomeride $[PtCl_2,2Sb(CH_3)_3]$ and the other an insoluble orange dimeride $[Pt, 4Sb(CH_3)_3]PtCl_4$ (*Trans. Chem. Soc.*, 1925, **127**, 185). With excess of the stibine both compounds are converted into a soluble tetrakistrimethylstibineplatinous chloride, $[Pt4Sb(CH_3)_3]Cl_2$, which forms a characteristic platinichloride $[Pt4Sb(CH_3)_3]PtCl_6$. These results show that the two products of the combination of platinous chloride and the stibine (2 mols) are not *cis* and *trans* isomerides.

VIII. Action of Sulphur Compounds in stabilising Cuprous and Aurous Salts

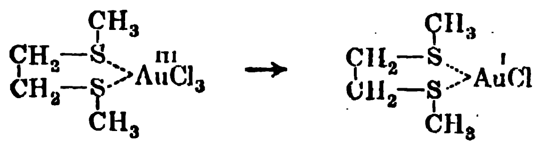
The sulphides of copper and gold obtained in qualitative analysis represent a partial reduction of cupric and auric salts inasmuch as the precipitates contain Cu_2S and Au_2S. This reducing action of hydrogen sulphide is reproduced when co-ordination compounds of copper and gold are prepared with the aid of addenda which contain sulphur.

Cupric chloride and bromide combine in molecular proportions with dimethyldithioethylene $CH_3.S.CH_2.CH_2.S.CH_3$ even in aqueous solution. The resulting complex cupric halides show a marked tendency to change into cuprous compounds, this instability being especially noticeable in the case of the dibromide.

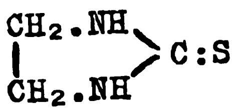


This diminution in the valency of copper is accompanied by a colour change from dark green to white.

A similar parallelism is observable in the case of gold salts. Auric chloride and the dithiol ether furnish a yellow complex aurichloride which in contact with moisture undergoes reduction to the white dimethyldithiolethylene aurous chloride (Morgan and Ledbury, *Trans. Chem. Soc.*, 1922, **121**, 2883).



More recently Mr. Burstall and the writer have employed ethylenethiocarbamide as a stabilising agent for the lower and more fundamental valency of the metals of the currency group with the result that remarkably stable aurous and cuprous complex salts have been isolated.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Cuprous Salts	*Aurous Salts*
$[Cu,3etu]_2SO_4$	$[Au,2etu]NO_3$
$[Cu,2etu]Hal$	$[Au,2etu,H_2O]Cl$
$[Cu,4etu]NO_3$	
$[Cu_2,5etu,H_2O](NO_3)_2$, $3H_2O$	
Hal = Cl, Br or I	

For comparative purposes these investigations have been extended to silver, although in this instance the lower valency of the metal is the one usually manifested. It is, however, noteworthy that trisethylenethiocarbamido diargentous persulphate is

a colourless crystalline substance stable up to 160° and that the complex silver chloride and bromide containing the thionated addendum are not affected by light.

Argentous Salts

$[Ag,4etu]NO_3$	$[Ag,3etu]Cl$
$[Ag_2,3etu](NO_3)_2$	$[Ag,2etu]Br$
$[Ag_2,3etu]S_2O_8$	$[Ag,etu]I$

Assuming that each molecule of ethylenethiocarbamide contributes two electrons, then the electronic structure of cuprous and silver ions in the nitrates $[M,4etu]NO_3$ corresponds with the structure of krypton and xenon respectively.

The cation of the aurous nitrate $[Au,2etu]NO_3$, although 4 electrons short of the structure of an inert gas, is a remarkably stable complex, crystallising unchanged from boiling solutions, and not reduced to metallic gold by formaldehyde.

The three complex nitrates from the currency metals dissolve in water to neutral solutions (P_H value about 6·2). Conductivity experiments indicate that they are almost as highly ionised in aqueous solutions as the corresponding salts of the alkali metals. It may be said that co-ordination of copper, silver and gold ions with a thionated addendum, such as ethylenethiocarbamide confers on the three currency metals the ionic properties of univalent alkali metals.

The interactions of thionated organic compounds and salts of copper, silver, gold, mercury and platinum have been studied in considerable detail by Sir Prafulla Chandra Ray and his co-workers (*Trans. Chem. Soc.*, 1919, **95**, 871). Considerable attention has been devoted to the varying valency of platinum with respect to mercaptanic radicals and suggestive results have also been obtained in a study of the complexes of gold chlorides with organic sulphides and mercaptanic radicals (P. C. Ray with K. C. Bose Ray, *J. Indian Chem. Soc.*, 1925, **1**, 63; 1928, **5**, 527; with D. C. Sen, *ibid.*, 1930, **7**, 67). In these researches, as in our investigations, thionated addenda tend to reduce gold to its univalent condi-

tion. It remains to apply these results to the chemistry of the naturally occurring minerals of the currency group of metals and especially those in which these metals occur in association with sulphur or its analogues.

Bengali Manuscripts at Evora

By Surendra Nath Sen (Calcutta).

The little town of Evora lies on a low hill in the midst of a fertile valley seventyfive miles from Lisbon. In size and population it hardly bears any comparison even with our small country towns but it occupies a deservedly high place in the history of Portugal. The ruins of a Roman temple, popularly associated with the goddess Diana, testify to its great antiquity and eighty years before the birth of Christ this obscure place formed the headquarters of Sertorious. In 712 Ebora, as it was then called, passed into the hands of the Moorish conquerors to witness four hundred and seventy years later a glorious triumph of the Christian arms. Here the great dramatist Gil Vicente, the greatest of his land, breathed his last and some of his "autos" or religious pieces were staged at Evora to divert his royal patron. In the 16th century Evora became the seat of an Archbishop and a University was founded in 1550. To-day Evora has hardly anything to boast of. The University is a thing of the past, the small museum attracts but few visitors, the cathedral is no more attended by the proud nobility, but the Public Library is rich in rare manuscripts and inquisitive students, though their number is necessarily limited, still make their pilgrimage to the capital of Alemtejo. Among its jealously guarded treasures are three Bengali manuscripts, two of which are unfortunately incomplete.

That Bengali manuscripts should find their way to this far off Portuguese town is no wonder, for Frei Manoel da Assumpcão was a native of Evora, and we are indebted to him for a Bengali grammar in Portuguese and a Bengali prose dialogue with a Portuguese version of the original text. These are now fairly well known to students of Bengali language and literature. *Crepar Xastrer*

Orthbhed or *Compendio dos misterios de fee* have been frequently referred to by many Bengali scholars and copious extracts from it as specimens of early Bengali prose, as it was written by a foreign student of the language, have been quoted by Prof. S. K. De in his *Bengali Literature in the 19th century* and Professors Suniti Kumar Chatterji and Priya Ranjan Sen in their edition of Manoel Da Assumpcão's grammar. There was a fairly large Christian community in the villages of Bhawal in the 17th century and it was urgently needed that missionaries well versed in the dialect of the district should minister to its spiritual needs. From a letter in the Cunha Rivara collection (Evora, Public Library) addressed by a Portuguese priest, Frei Alvaro da costa, in 1682 to his friends at home it appears that he found many Christians in Bengal, particularly in an island called Ramnacor (Ramnagar) but they had not seen a Padre for many years. Frei Manoel da Assumpcão was Rector or Head of the Mission of Saint Nicholas Tolentino in the province of Bengal in 1735 and things seem to have considerably improved in the meantime. It was for the benefit of the missionaries, who were expected to make new converts and to look after the moral and spiritual welfare of their flock that Frei Manoel compiled his grammar and vocabulary and the dialogue. Both of these works were dedicated to Dom Miguel de Tavora, Arch Bishop of Evora, and were printed simultaneously in 1743 at Lisbon by Francisco da Sylva, under the supervision of Frei George da Apresentacão, who was probably an intimate friend and colleague of the author. The grammar and vocabulary seems to have received but scant attention at the time, for Diogo Barbosa Machado does not metion it in his *Bibliotheca Lusitana* published only nine years later. Nor does he give any detail about the life and occupation of Manoel da Assumpcão that cannot be gathered from his title page. Innocencio Francisco da Silva, who brought out his *Diccionario Bibliographico Portuguez* in 1840, refers to this omission on the part of Barbosa but observes that the book had already become rare and he saw only one copy in Libraria de Jesus. *Crepar Xastrer Orthbhed* seems to have been more popular and went through a second edition in 1869. The second edition was

published at Margao near Goa and copies of both the editions are to be found in the Biblioteca Nacional of Lisbon. The Calcutta copy unfortunately lacks the title page and the preface and I need not offer any apology for reproducing them here. The title runs as follows :

Crepar Xaxtrer Orth Bhed
Xixio Gurur Bichar

Fr Monoel da Assumpcām, Liqhiassen, O buzhaiassen Bengallate Baoal dexe, xon hazar xat xohopointix bossor Christor zormo bade. Bhetton cooilo boro thacurque D Fr Miguel de Tavora Evorar xohorer arcebispo.

Lisboate Frarcisco da Sylvar xaze, Pataxaer quitaber xap sorinia xpor zormo bostore 1743.

Xocol uchiter hucume

It will be perceived that Manoel da Assumpcão and his printers had for obvious reasons to make use of Roman scripts. Probably the author thought that it would be too much to expect the new arrivals from his country to learn an unfamiliar script as well as a novel tongue. "Xocol uchiter hucume" seems to be the literal translation of "com todas as licencas necessarias," not a happy rendering in any case. In the preface the Bengali reader is addressed as follows :

Bengallire Poroho Zanan

Doxto Bengali, Xono : Puthi xocoler utom puthi, Xaxtro xocoler utom xastro ; Xaxtri xocoler utom xaxtri Christor Xaxtri, Crepar xaxtro ebong crepar xaxtrer puthi.

Ehi puthite xon mondia paiba buzhon, buzhan, buzhibar, buzhaibar upae toribar. Axtar bedher ortho xono, xonao ; porthoquie zania buzho, buzhao porinamer ponth dhoro, dhorao ; xixio Gurur niate niae corite xiqhao ; eha zania, buzhia, mania mucti hoibeq ; dox agguia palon coro zodi.

The Bibliotheca publica of Evora possesses an incomplete manuscript of this work. The opening lines differ slightly from the opening lines of the published book and the last page concludes thus :

P. xorir zia utthon quemon buzho ?

Z. Buzhi, ze xocol manux, bala ar bura zia uthibo moha proloyer din xorir, ar atua xomet bichar hoite.

Of the grammar Evora possesses only a printed copy but on p. 141 of the above-mentioned manuscript ($\frac{C \times V_1 E}{1-1}$) we come across a fragment of a Dictionary which may be reasonably ascribed to Frei Manoel. Here he starts with an effort to supply the colloquial and polished Bengali as well as Hindusthani synonyms of Portuguese words. But after a few pages he gives up his attempt probably because the task was beyond his capacity. The Dictionary consists of 22 pages only, many of which are blank, and ends with the phrase "depois de amanha-calicarpor." The third manuscript is luckily complete except for a few lacunae evidently caused by the depredations of worms. It was first noticed by Cunha Rivara in his descriptive catalogue of the manuscripts at Evora. We learn from the title page that the author was "that great Christian Cathecist who converted so many Hindus, called D. Antinio, son of the king of Busna." Of Dom Antonio we know but little. He was taken captive to Arakan in 1663 and was subsequently ransomed by a Portuguese priest, Manoel de Rozario, who converted the Bengalee prince. When exactly this dialogue was written we do not precisely know but it can be safely surmised that this manuscript supplies specimens of the later seventeenth century Bengali prose. The language is naturally more chaste than that of Fr. Manoel da Assumpcão and the best portion bears comparison with the less sanscritised portion of Mrityunjaya Tarkalankar's *Probodh Chandrika.* It also illustrates the persistency of some Eastern Bengal proverbs which still run current. The title page and the prologue are in the handwriting of Fr. George a Appresentaeao and the Portuguese version was made by the indefatigable head of the mission of St. Nicholas Tolentino. The translation is not literal but it gives the general sense fairly correctly. Probably when Frei Manoel da Assumpcão sent his grammar and dialogue for publication at home he also sent the earlier work of Dom Antonio with the same intention, for we cannot otherwise explain his prologue. Dom Antonio does indeed make several references

to Crepar Xaxtro but it does not follow that he alludes to the work of Frei Manoel. Crepar Xaxtro was probably known in an earlier Bengali version. As is apparent from the title Dom Antonio aimed at demonstrating the falsehood of Hinduism and to establish the superiority as well as the infallibility of his own faith. His book, therefore, is written in the form of a discussion between a Roman Catholic and a Brahman and as it can be easily guessed the Roman Catholic had the best of the debate. The dialogue opens with an examination of the Hindu theory of predestinaton and then the ten incarnations of the Hindu mythology are discussed in detail: The Brahman next goes on to explain the Hindu trinity which is also rejected by the Christian. Finally some of the popular religious practices and rites are reviewed and the Brahman is converted to the views of the Roman Catholic. The dialogue ends rather abruptly.

Dom Antonio had one advantage over the Portuguese missionaries. He was more familiar with the religious beliefs and supersititions of his countrymen than the foreign priests and as Bengali was his mother-tongue he uses its idioms with greater success and more freedom than Frei Manoel. But at times Dom Antonio betrays the superficial nature of his acquaintance with the Puranas, for he includes Krishna Vasudeva among the ten incarnations. Nor is his version of other Pauranik incidents free from inaccuracy. But we do not turn to this rare manuscript as a reliable discourse on popular Hinduism; it is to be prized as the earliest known prose work in Bengali and as such is its value to be assessed.

The prose of Dom Antonio is simple but it cannot be claimed that he always used the colloquial language of his time. Although the vulgar word is not systematically excluded, the author does not hesitate to use the more polished language which the learned alone would appreciate. It is not the place to discuss the method of transliteration, suffice it to note that the same word is sometimes differently reproduced in Roman script. The text covers 120 pages quarto of foolscap, in one column is reproduced the original text while the Protuguese version is written opposite. There are in the text several Sanskrit quotations, but the transliteration is in these

cases so unsatisfactory that I have not been able to restore two of them.

The major portion of the text was copied by me during my sojourn in Portugal. The text has now been prepared for the press and will, I hope, be of some use to more serious students of Bengali language when published.

The Portuguese were responsible for many misdeeds in Bengal, they are remembered to-day as ruthless pirates. But they certainly deserve our praise and appreciation for the valuable service their missionaries rendered to our mother-tongue. Had Manoel da Assumpcão done nothing but compiling his grammar and vocabulary he would still be entitled to our homage of gratitude, but he did somtehing more. It was he and his friend George da Apresentacão who were responsible for preserving the earliest known prose work of a native born Bengali and it was rescued from oblivion by a Portuguese scholar, the late Sir J. H. da Cunha Rivara. Let us forget Gonzales and remember Manoel and George.

Breeding Work on Rice (*Oryza sativa L.*) in Assam

By S. K. Mitra (Jorhat).

The fundamental basis of experimental plant breeding lies in the raising of pedigreed cultures of plants. The application of this method has given a great stimulus to plant breeders to improve the cereals during the past thirty years. Undoubtedly the studies in plant genetics since 1900 as well as the development of field technique have furthered the cause in a large measure to standardize methods of breeding. Definite information regarding better methods of selection and the nature of inheritance of particular characters is being added year after year.

The problem of the plant breeder to-day is to originate a desired variety that suits the purpose of the cultivator in giving an increased yield or improved quality that will give him a better profit. So far as our work on rice is concerned we are working mostly for the quantity and so very little for quality, as the latter is not so well recognized by our common cultivators. Such being the case the Indian plant breeder has to take yield as his first consideration, although he may improve the quality and yield simultaneously having the quantity as the desired end in view. But one fact that an individual plant breeder should always have to bear in mind is that a variety recommended to the cultivators should have a wide range of adaptability in a province at least within a large area.

Unlike wheat the adaptability of rice is very limited. The well known Pusa 4 wheat developed by the Howards is being extensively grown successfully in such diverse places as in the North-West Frontier Province, Oudh, Bihar and the well-irrigated tracts of Central India. Such a case of wide adaptability in rice

is not known. Observations at the Government rice experiment stations in Assam have shown that, except a few selected varieties from Bengal, all the recommended varieties of other sister provinces as well as from outside of India are of very little use. However, it may be said that such varieties as As. 2 Basumati (Autumn rice) and S. 22·Lati sail (Winter rice), developed at the Government rice station at Karimganj, have proved successful covering a large area in both valleys of Assam.

Improved varieties of rice may be produced by two methods, viz., selection and hybridization. It has been said of a Chinese Emperor Kiang-Hisi (1662-1723) that while walking in the field he observed a stalk of rice in ear which was higher and far ahead of all the rest in maturity. He ordered it to be preserved and this was the origin of one of the best commercial rices in China. It was a mere chance selection. We do not know of any record whether such a variety was ever developed in India. However, it may safely be said that like their brethern, the Egyptians and the Chinese, the cultivators of Assam developed a knowledge of selection of rice ears and that old custom survives even to-day in some quarters.

In plant breeding the modern geneticists' methods and technique in the selection and hybridization of plants grown in the field and analysed in the working room by well developed statistical methods resemble the chemical analysis of a chemist in his laboratory. Recent investigations in chromosomal theory, on which the modern theory of heredity is based, have started a new age in genetics and it is really a pity that authoritative work on this line (Cytology) is still wanting in India.

The development of the idea of heredity and the pure line types for which we are indebted to Gregor Johann Mendel and W. Johannsen respectively, has enabled the plant breeders to obtain suitable varieties in a reasonable period of time. How attempts are being made to follow the means and methods of these two theories in rice at the Government experiment stations in Assam will be discussed here briefly.

1. Pure line selection.—As the improvement of the quality

of seed is undoubtedly the best inexpensive method of increasing the yield per acre that can easily be adopted by the cultivators, the work on pure line selection has been resorted to. Accordingly a large number of samples (about 650) were collected in the two rice stations and over 2,200 types isolated as pure. A series of varietal tests were conducted in each class of rice such as *aus, sail* and *asra.* When a variety or type gives constantly high yields over a three to five year period both in varietal experimental plots as well as under field scale observation, it is then recommended to the cultivators.

In order to compare a high yielding variety against a standard, a locally known paddy, the "checker-board" method is adopted in 10 ft. × 10 ft. plots replicated in 12-24 times or more. About 200 seedlings are transplated in each plot out of which hundred plants from the inside rows are collected and weighed for experimental purposes. The results are then tabulated and statistical methods are employed for the computation of certain mathematical constants which express the characteristic features of the types under comparison in comprehensible terms. As a result of successful selection twenty-nine varieties or types have been recommended to the cultivators and are being grown successfully in many localities. It may also be mentioned here that "the Latin square" and "Randomized block" methods have recently been introduced in comparing the high yielding varieties of rice.

2. Hybridization.—The improvement of rice by cross-fertilization is a subject which is not only very difficult in its operation, but does not produce any immediate result as that met with in the case of pure line selection. As a result of successful crossing, the evolution of a new type which satisfies the conditions in yield as well as in vegetative characters, such as erect straw, awnless and uniform grains, dense panicle etc. entails six or seven years continually.

The question may arise whether a particular rice that is being grown in a locality as a well-known crop is pure. This question can only be solved by cross-fertilization. According to the law of Mendelian inheritance the characters of the two parents in a cross of F_1 (first filial) generation come out distinctly in F_2

(second filial) generation, where both pure and mixed types are produced. This is known as "Mendelian segregation" which will be discussed later.

Inflorescence.—The rice inflorescence consists of a panicle on an extended pedicel with branchlets bearing the rice flowers or spikelets. The flowers are perfect with six stamens. The grain is oblong or obtuse tightly enclosed in the glume or hull. Generally the rice plants open their flowers after sunrise at about 9 A.M. or 10 A.M. At this time the two inner glumes open at the top and the pollen-bearing anthers come out. The glumes close after a short time and the pollen sacs remain hanging outside by the thread-like filaments.

Observations on the opening of rice flowers show that the days required for the opening of all the flowers in a panicle vary from 5 to 9 days. Moreover, flowering is vigorous from the 2nd to the 5th day and the maximum rate of flowering is obtained on the 2nd or 3rd day. Except in the rainy or cloudy days flowering begins at 7-30 A.M. and continues up to 12-30 P.M.

Natural cross-fertilization.—It may be stated at the outset that the male element is the pollen and the female element is the pistil bearing the ovary within. Although the rice flowers are perfect and mostly self-fertilized, cross-fertilization sometimes occurs which may be caused mostly by wind. In Bengal Hector (1913) found cross-fertilization to occur in rice to an extent of about 4 per cent. Parnell et al (1917) in Madras found it to be between 0·1 and 2·9 per cent wih an average of 1·4 per cent on experimental basis. The observation of the writer and his assistants showed that natural crosses do not occur more than 0·5 per cent on average under Karimganj conditions. This lower percentage of natural crosses in Assam is perhaps due to heavy rains during the *aus* flowering season and the dewy mornings during the *sail*, both of which prevent the pollen from being transferred easily.

Artificial cross-fertilization.—The purpose of artificial cross-fertilization in rice is to originate some new types that may suit best the climate and the soil for which it is intended and give a comparatively higher yield than any of the existing varieties. Cross-

fertilization also brings forth in the progeny the Mendelian inheritance of characters in rice as well as the pure strains of the parental varieties dealt with. Such a work has a scientific value of its own as well as a direct economic value on the line of genotypic selection, i.e., the breeding of improved pure strains.

Actual operation.—When it is required to pollinate by artificial means, it is always necessary to protect the essential parts of the flowers. This is to be followed in the case of spikelets of the panicle that are chosen for cross-fertilization. The flowers, from which the pollen is to be used, should also be separated carefully in order to prevent the mixture of foreign pollen after the opening of the flowers. The anthers bearing the pollen of the flowers, which are to be used for crossing, should be removed before the dehiscence of the pollen sacs. This operation is called *emasculation.*

In Assam the majority of the rice flowers open from 10 A.M. to 11 A.M., although differing to some extent with the season and atmospheric conditions. Anthers are, therefore, removed early in the morning (6 A.M.), when there is very little chance of dehiscence of the pollen, care being taken to select such flowers as are expected to open on the same day. The glumes which in some cases tend to remain slightly open are kept closed by a small rubber ring cut from an ordinary cycle valve tube. The emasculated flowers are pollenised when the anthers mature at about 10 A.M. In so doing the individual anthers are held by a pair of forceps and brushed against the bifurcated feathery stigma. At this stage the pistils are in a receptive condition and pollination takes place easily. After the pollination the two inner glumes are kept closed by the same rubber ring as stated before just to hold the grain intact and free it from exposure. When this crossed grain is mature, it is stored carefully to be grown in the next season.

F_1 generation.—The crossed grains, as stated above, are grown separately in the next year. The vegetative characters of the individual plants are to be studied in detail from germination to maturity. After the collection of the mature panicles the dominant characters of the crossed plants are easily noticed.

F_2 generation.—In the next year the seeds obtained from the F_1 plants are grown singly and the result is the Mendelian segregation of parental characters, i.e., the harvested grains, when examined, show the characters of their parent plants in some, and new combinations of parental characters in others, showing dominant and recessive characters in a 3 : 1 ratio.

The segregation of parental as well as mixed characters becomes distinctly visible when the resulting seeds of F_2 are grown in the 3rd year, which will give the seeds of F_3 generation. The latter in their turn, when grown in the fourth year, will give out a segregated progeny as before, of which some will be pure as their parents (both mother and father plants) and the rest will be a mixed progeny as before. It is from the pure types, thus obtained, that the selection work is to be continued so as to get a desirable fixed character which will suit the need of the cultivators.

In their work on cross-fertilization Hector (1922), Parnell et al (1917 and 1922) and Ramiah (1930 and 1931) have realized the difficulty of working with so many different varieties with their respective colour combinations exhibiting in various parts of the plants as well as characters such as awn, outer and inner glume, size and shape of grains (unhusked) etc. In a previous publication (Mitra, Gupta and Ganguli, 1928) the writer with the help of his assistants has dealt with the colour inheritance in rice. He has also studied the vegetative characters mentioned above and some species crosses (Mitra and Ganguli, 1932).

Some of the characters in rice, such as awn, glutinous endosperm, colour of inner glume etc. have a bearing on the relative appearance and market value of the grains. They are of great economic importance to a plant breeder. In the work of rice selection at the Government rice experiment station at Karimganj, Sylhet, it was noticed that a high yielding variety may have long awns or weak straw, both of which are undesirable characters from the economic point of view. Moreover, a variety may have uniform long grains with glutinous endosperm, while others may have short grains with translucent endosperm. In all such cases the undesirable characters make a variety unpopular, although it

may have a higher yield than others. It is with a view to study these characters and, if possible, to combine desirable traits, apparently inherent in individual varieties, that a large number of crosses were tried and their genetic data for successive generations carefully studied and mathematical constants calculated for the "goodness of fit" in the Mendelian ratio involved in comprehensible terms. To the credit of the Karimganj rice station it may be stated that it has been able to give out two types of hybrids, viz., Karimganj 1 and Karimganj 2, which have proved very successful in cultivators' fields, while there are four more hybrid types showing promising results under comparison.

In conclusion, I may point out that a question may arise about the need of mathematics to agricultural science. In answer to this I may say that the use of mathematics to biological science is not to show an air of erudition or is an end in itself, but only as a means to an end. The aim of a plant breeder is to continue his work systematically on research in a line and give a proper interpretation of related facts. The production of fruitful results, having an economic and scientific value and not mere collection of data, is really the goal of a research worker on plant breeding.

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A Micro-Chemical Method for Detection, Separation and Estimation of Nickel and Cobalt

By N. C. Nag (Calcutta).

In the Zeitschrift fuer anorg. Chemie[1] I described a few observations on certain reactions of Cobalt and Nickel salts. Sir P. C. Ray in communicating the paper added a note :—"Die oben beschriebenen Reactionen wurden in der letzten Wochen des März 1896 Herrn Nag beobachtet und ich riet ihm, die untersuchung fortzusetzen und wenn moeglich, die neue Verbindung zu isolieren. . . . . ."

The occasion of the old Master's 70th Birthay celebration has stirred in me the old, but never to be forgotten, memories of encouragement I then received.

The main point is the production of a *deep violet coloured precipitate of a Nickel compound* and of a *green coloured solution of a Cobalt compound* which are formed when their salts in solution are treated with an excess of alkali-bicarbonate and bromine. The reactions are delicate enough to be applicable as micro-chemical tests for the separation and quantitative estimation of Nickel, gravimetrically by micro-chemical balance and volumetrically by N/100 oxalic acid and permanganate or by N/100 iodine-thiosulphate, Cobalt being determined colorometrically.

In the present paper I shall deal with the Nickel compound only.

1 Zeit für anorg. Chemie, Band XIII, 1896.—Ueber neue Kobalt und Nickelsalze von Nagendra Ch. Nag.

Experimental

(*a*) One gram of nickel ammonium sulphate, $NiSO_4 . (NH_4)_2 SO_4 . 6H_2O$, is dissolved in 100 c.c. of water. This contains in one cubic centimeter 0·001488 gram Nickel.

(*b*) One cubic centimeter of the above solution is further diluted to 100 c.c. One c.c. of this latter diluted solution contains 0·00001488 gram Nickel.

Qualitative Tests

For mere detection, one drop of the mere dilute solution (b) is taken in a small crucible or a narrow small test tube, a little solid sodium or potassium bicarbonate dropped in and the liquid saturated with bromine vapour. The vessel is then gently heated on a micro-water-bath as is generally used in micro-chemical tests. The characteristic reactions are easily noticed with the unaided eye. In the microscope and spot-test method even lesser quantities may be used.

Quantitative Estimations

I shall illustrate these by quoting actual figures from my note book.

Gravimetric:—0·50 c.c. of the solution (a) was taken in a micro-beaker (improvised for the purpose, cap. 1·5 c.c.), a pinch of solid sodium bicarbonate added and bromine vapour applied to saturation. The beaker with the now yellow liquid was placed on a micro-water bath. With the disappearance of the yellow colour of the liquid a deep violet precipitate was formed (some of which gets attached to the sides of the experimental beaker and are not easily detachable). After precipitation and cooling, the beaker with its contents was placed into a Jena glass filter funnel and fully washed with distilled water using a gentle suction by a water pump. The *precipitate with the beaker in the funnel* was then dried in an air oven (temperature 90°C) and finally weighed to constant weight in a micro-chemical balance (Bunge Assay Balance carrying upto 20 grams and adjusted sensitive to one-thousandth of a milligram when the pointer scale is read with a magnifying

lense from outside the Balance Chamber). The difference between the previously determined weight of the washed and dried funnel with the beaker, and the weight with the precipitate gave us the weight of Ni_2O_3.

Weight of the glass filter funnel and beaker with precipitate	... ...	17·322947 gram
Weight of glass filter funnel and beaker	...	17·321900 gram
Weight of precipitate	... ...	0·001047 gram

The quantity actually found by weighing agrees exactly with the quantity theoretically calculated from the amount of nickel ammonium sulphate taken in 0·50 c.c. of solution (a).

Theorectical for Ni_2O_3....................0·001047 gram.

Volumetric.—The above quantity of Ni_2O_3 was then dissolved in 10 c.c. of N/100 oxalic acid by placing the micro-beaker with the glass filter funnel in a larger sized beaker and titrated with N/100 permanganate after addition of dilute sulphuric acid and warming. This required 8·70 c.c. of N/100 permanganate, leaving 1·30 c.c. for oxygen supply from the nickelic oxide. The oxygen quantity from the above result comes to $0{\cdot}00008 \times 1{\cdot}30 = 0{\cdot}000104$ gram corresponding to 0·00107 gram of Ni_2O_3—a somewhat higher figure than required by theory. A more dilute solution of the standards used gives better agreement.

In a similar experiment with 0·50 c.c. of solution (A), as above, the precipitate of Ni_2O_3 was treated with a solution of potassium iodide and Hydrochloric acid, the liberated iodine being estimated by N/100 Thiosulphate. The titraton was carried out in a suitable wide-mouthed glass-stoppered bottle for proper manipulation. The result was closer than with permanganate.

It has been found quite feasible for volumetric work to use Schleicher and Schull's No. 589 filter paper (White Band), which allows quick filtering, so that the whole operation for estimation from the beginning to end does not take more than 20 minutes. In the case where the estimation is made from iodine liberation, the filter paper material often serves as the indicator and does not

require an additional drop of starch solution. In a particular case, the liberated iodine was equivalent to 1·27 c.c. of N/100 thiosulphate. This corresponds to $Ni_2O_3 = 0{\cdot}001050$ gram while the theoretical quantity taken was 0·001047 gram.

It will be observed that both gravimetric and volumetric estimations gave concordant and close results.

Experimental results with Cobalt solutions as also some other facts regarding nickelic oxide and preventing its getting attached to the sides of the experimental vessels will be the subject of a future communication elsewhere.

Summarising the above facts it may be said—Bicarbonate + bromine test for Nickel (and Cobalt) is applicable as micro-test for detection and quantitative estimation, both volumetrically and gravimetrically. This test compares favourably with those given in standard works.[2]

2 Emich-Schneider—Microchemical Laboratory Manual with a section on Spot Analysis by Dr. Fritz Feigel (1932).

Chamot and Mason—Handbook of Chemical Microscopy, Vol. II (1931).

Pregle-Fyleman—Quantitative Organic Micro-Analysis (1930).

Sir P. C. Ray—A Radical Thinker

By Sachin Sen (Calcutta).

Sir P. C. Ray does not belong to a world that is past; he does not speak in a language of the past; he takes a dynamic view of men and things, he examines and receives ideas after they are found immalleable in the furnace of criticism—these are the virtues that have made him great. In a country which is governed by slokas and shastras, atrophied by traditions that have no merit save their age, asphyxiated by a false sense of dignity,—it is really a pleasure to find a hero determined to uproot stale thinking and substitute a newer and more vigorous conception of life. We are clogged and hampered with the compulsion of unmeaning rites; our strength is exhausted by our social ceremonials—"from birth ceremony, through the whole series, to death ceremony—exerting their way over both this world and the next, that we are bereft of the energy to take any step forward"; the accumulated rubbish in the society has made our mind dead, arms weak and intellect uninquisitive; "speculative explanations, metaphors hardened by usage into quasi-factual statements, fantasies arising out of germinating and suppressed impulses, false analogies, parables begotten and distorted, dogmatic excesses, the odd compromises of theological diplomatists, the craving for super-natural sanctions"—all have mingled inextricably in our religious fabric; our pitiable immobility, "shrieking to the dead ghosts of the past to save us and living as a putrid and stinking corpse instead of as a living and self-renewing energetic creature", is nauseating and suicidal. Against all these vices and wastages, Sir P. C. Ray has raised his banner of revolt. He stands for the mobility and adventurousness of the race, for the freeing of shackles and prohibitions of all kinds about the most insignificant details of our daily career chloroforming our

lives insulated in the confinement of our conventional solitary cell, for the establishment of perfect co-operation of life and mind. He knows that stagnation is death and movement is life; the weak must perish and the strong would win; truth is not for beggars but for seekers; vindictive self-assertion is an invariable characterestic of the hopelessly damned, whereas harmonious unity which does not nourish a spirit of rejection but furthers glad acceptance is the ideal of lovers of humanity; the serene light of freedom can only be enjoyed by those daring travellers who have been out to win the world outwardly and inwardly, but not by those householders who pine away their existence under the cartloads of household burdens and who are filled to the brim and loaded to breaking point with lifesucking rubbish in the dust-bins of the society.

In our country life does not grow and blossom; the people surround themselves with a hard incrustation of the most narrow and obsolete prejudice. They do not live in fulness; they merely pass their days and drag their existence. Sir Prafulla is an iconoclast in this respect: he suffers no injustice, brooks no irrationality, respects no tutelage. He is out to purge the society of its evils, indoctrinate the country with rational and bold ideas, and champion the cause of righteousness, untinged by timid religiousity. He is liberal in ideal and catholic in outlook. His mind is fertilised to receive and accommodate new ideas. Logic and not magic makes an appeal to him; and neecssarily he detests conservatism which hampers growth, hammers new thoughts and hinders rational intercourse. As a scientist, he has brought scientific outlook in all his activities. He observes, he examines, he analyses and then he gets at truth. The scientists respect nothing but truths and nothing is truth which cannot be proved. That is what is called scientific attitude and this attitude he has preserved not only in his laboratory but also in other activities of life. There he is a radical thinker—a thorough reformer in politics and society. He does not believe in accepting old things; he has faith in receiving new things. That is what strikes me most in the life of Sir P. C. Ray.

Sir P. C. Ray is one of those who subscribe to the creed that

no political miracle can be built on the quicksands of social slavery. Accordingly, he is a firm believer in the reforms of the society. He has felt that the world is man-made and civilisation is masculine; the society has been designed and shaped in a way which makes great injustice to women-folk. Sir Prafulla has strenuously fought for the emancipation of woman from the trammels of the society and its outworn ideas. He advocates late marriage which gives a new dignity to women, widow-remarriage which blots out inferiority complex in women, free mixing of men and women which brings the whole of mankind on an equal plane without relegating either section to any subordinate place. He is a believer in the democratisation of the society: it is merit and not heredity that will count; equal opportunities should be thrown to all and no class should suffer from any disability. He is also a believer in the economic interpretation of the society: people who are not economically potent factors have no place in his scheme of the society; the idle rich class who do not contribute stand condemned in his scheme.

Sir P. C. Ray is a fighting thinker—he fights against injustice and abuses. When he sees in the political field that any injustice is being inflicted on the people at large, he fights relentlessly. When he sees the abuses of Bengalee genius working in unproductive channels, he raises the alarm fearlessly. In his brochure (in Bengalee) "Abuses of Bengalee genius," he pointed out how the Bengalee brains were employed in weaving fetters after fetters on the society on the plea of rites and ceremonials; that was a grim tragedy in the history of the Bengalee race. In his view, the present system of university education by giving undue stress on the literary side and totally neglecting the vocational aspect is absolutely unsatisfactory and fouling the reputation of Bengal. He has never stopped to give wide publicity to his view and in fact he said on one occasion—"If I am made the dictator of the university for one day, I would shut down the Law Department for at least three years." He holds that the best of our youngmen are exhausting themselves in bleak obscurity in legal lines in lure of a phantom which comes in the case of a very few. In the interest of the babe

of a future aeon, he advocates vocational training and is averse to divorce education from life.

Sir Prafulla Chandra is also a constructive thinker. He believes in the industrialisation of the country. A Bengalee, he says, is loath to work; he has false sense of dignity and undue craze for university degree. He always rebukes the idle and chastises the depraved. He condemns the fissiparous tendencies of the age.

"Words are silvern, deeds are golden." Sir P. C. Ray believes in deeds, he shines in deeds, he does not exhaust himself in mere words. He thinks and acts and leads others to act. As a scientist, he is quick and precise, practical and accurate. And also as a scientist, he has boldness in thinking and in exploring new thought-regions. He does not like to live, move and have his being in "inverted commas"; he wants independent thinking.

আচার্য্য ডাঃ সার প্রফুল্লচন্দ্র রায়

আচার্য্য প্রফুল্লচন্দ্র সম্বন্ধে সংবাদপত্রে বা সাময়িক পত্রে যাহা প্রকাশিত হইত তাহাই পাঠ করিয়া মনে মনে তাঁহার প্রতি শ্রদ্ধা-অর্ঘ্য নিবেদন করিয়া নিশ্চিন্ত ছিলাম। তখন ভাবিতে পারি নাই যে প্রীতির আকর্ষণে তাঁহার সম্বন্ধে কিছু লিখিবার জন্য আমার উপর প্রেমের আহ্বান আসিয়া পড়িবে। কিন্তু সংসারে অনেক অসম্ভব ঘটনাও ঘটিতে দেখা যায়, আমার উপরেও ডাঃ রায় সম্বন্ধে লিখিবার জন্য অনুরোধ অকস্মাৎ আসিয়া পড়িল। কোথায় তিনি, কোথায় আমি। তিনি বিজ্ঞানসাগরে সন্তরণদক্ষ সুপণ্ডিত; আর আমি প্রজ্ঞানসাগরের তীরস্থ বালুকণা সংগ্রহে অভিনিবিষ্ট। তদুপরি বর্ত্তমানে আমি "দৃষ্টিহীন ও নাড়ীক্ষীণ" সম্প্রদায়ের একজন হইয়া আছি। এখন আমার পক্ষে আচার্য্য রায় সম্বন্ধে এদিকে ওদিকে ছুটিয়া গিয়া কিছু জানিবার চেষ্টা করার অবকাশও নাই, আর ক্ষমতাও নাই; কিন্তু তিনি আমাদের এতই অন্তরঙ্গ যে তাঁহার বিষয়ে লিখিবার অনুরোধ কিছুতেই উপেক্ষা করিতে পারি না।

তাঁহার সম্বন্ধে কিছু বলিতে গেলে সর্ব্বপ্রথমেই তিনি যে কি রকম মানুষ তাহাই বুঝিতে ও বুঝাইতে লেখনী ধাবিত হয়। সভাসমিতিতে তাঁহার সহিত আমার দুই চারিবার চাক্ষুষ আলাপপরিচয় হইলেও অনেক দিন যাবৎ আমার বড়ই দুঃখ ছিল যে তাঁহার সহিত প্রত্যক্ষ ও ঘনিষ্ঠতরভাবে পরিচিত হইতে পারি নাই। অবশেষে এক বন্ধুর সহিত পরামর্শ করিয়া শতাব্দীয় মাঘোৎসবের রবিবারে তাঁহার সহিত উভয়ে দেখা করিতে গেলাম। আমাদের আশঙ্কা ছিল যে, ডাঃ রায় যেরূপ কাজের লোক তাহাতে হয় তো তাঁহার সহিত সাক্ষাৎ হইবে না, কিন্তু সম্ভবতঃ রবিবার বলিয়া আমাদের সে আশঙ্কা নিরর্থক হইল—তাঁহার সহিত দেখা হইবার কোনই বাধা ঘটিল না।

বিশ্ববিদ্যালয়ের বিজ্ঞানমন্দিরের এক প্রকোষ্ঠে তিনি বোধ হয় আহারান্তে বিশ্রাম করিবার ব্যবস্থা করিতেছিলেন। দেখি, তিনি একটী ক্ষুদ্রায়তন

চারপায়ায় শয়ান, কিন্তু জাগ্রত। দেখিয়া আমার মনে হইল এই দরিদ্র দেশের অধিবাসী যিনি এবং এই দরিদ্র দেশের অধিবাসীদিগের সেবাব্রত যিনি প্রাণের সহিত বরণ করিয়া লইয়াছেন, তাঁহার পক্ষে এইরূপ চারপায়াই বিশ্রাম করিবার উপযুক্ত উপকরণ। এত বড় বৈজ্ঞানিক যে গৃহ অধিকার করিয়া আছেন, সেই গৃহের কোথাও বিজ্ঞানের "ব" হইতে "ন" পর্য্যন্ত কিছুই দেখিতে পাইলাম না। না ছিল কিমিয়াবিদ্যার উপযোগী একটী বোতল আর না ছিল কোন প্রকার রাসায়নিক উপকরণ। তিনি আমাদিগকে দেখিয়া শয্যা হইতে গাত্রোত্থানপূর্ব্বক সাদরে অভ্যর্থনা করিলেন, প্রায় এক ঘণ্টা কাল ধরিয়া ব্রাহ্মসমাজ, বিজ্ঞান, খদ্দর, প্রভৃতি নানা বিষয়ে আলাপ আলোচনা চলিয়াছিল। সমস্ত আলাপআলোচনার ভিতর বিজ্ঞান বিষয়েই হউক বা খদ্দর প্রচার সম্বন্ধেই হউক তিনি নিজে যে কত গুরুতর বাধাবিঘ্ন অতিক্রম করিয়া সফলতা লাভ করিয়াছেন—এক কথায় তাঁহার নিজের কৃতিত্বের বিষয়ে একটী কথাও তাঁহার মুখ হইতে বাহির হইল না। এত বড় বৈজ্ঞানিক ও মনীষী ব্যক্তি যে কিরূপ নিরহঙ্কার শিশুর ন্যায় সরল প্রকৃতি সেইদিন তাহা প্রত্যক্ষ করিয়াছিলাম। আজকালকার দিনে এ'প্রকার বিজ্ঞতার সঙ্গে সরলতায় মাখা মানুষ পাওয়া যে কি প্রকার দুর্লভ, তাহা হয় তো আমার না বলিলেও চলে। কথালাপের পর এই শিশুপ্রাণ পণ্ডিতের নিকট বিদায় লইয়া ফিরিয়া আসিলাম। সে চিত্র এখনও আমার নয়নের সম্মুখে ভাসমান।

বিজ্ঞান অনেকেই অধ্যাপনা করেন ও করিতে পারেন, কিন্তু ছাত্রগণের উপর সকল অধ্যাপকের কেমন একটা সুদৃঢ় ও সুগভীর প্রভাব ও অধিকার থাকিতে সচরাচর দৃষ্ট হয় না। আচার্য্য প্রফুল্লচন্দ্রের প্রভাব ও অধিকার কিন্তু ছাত্রগণের উপরে আশ্চর্য্যরূপ বিস্তৃত দেখা যায়—ছাত্রগণের মধ্যে তাঁহার নাম যাদুমন্ত্রের ন্যায় কার্য্য করে—ছাত্রগণের নিকট his name is one to swear by and to conjure with। ইহা একটী মনস্তত্ব বিষয়ক সত্য যে প্রীতি প্রীতিকে আকর্ষণ করে। এই মহাবৈজ্ঞানিকের বৈজ্ঞানিকতা নহে, কিন্তু ছাত্রদিদের প্রতি তাঁহার অনুরাগ ও প্রীতি উহাদিগকে তাঁহার প্রতি আকর্ষণ করে এবং পরস্পরকে এক আশ্চর্য্য সখ্যসূত্রে আবদ্ধ করে। পুরাণাদিতে আচার্য্য ও শিষ্যদিগের মধ্যে যে একটী প্রীতিমূলক সম্বন্ধের বিষয় যথাতথা উল্লিখিত দেখি, আচার্য্য রায় ও তাঁহার ছাত্রবর্গের মধ্যে সেই মধুর

সম্বন্ধ সম্পূর্ণ জাগ্রত দেখিতে পাই। ডাঃ রায়ের আচার্য্য উপাধি সম্পূর্ণ সার্থক হইয়াছে।

আমার ন্যায় নিতান্ত অবৈজ্ঞানিকের পক্ষে বিজ্ঞানের দিক হইতে প্রফুল্লচন্দ্রের ন্যায় বৈজ্ঞানিকের সম্বন্ধে কিছু বলিতে যাওয়া ধৃষ্টতা হইবে, তাহা বিলক্ষণ জানি। কিন্তু দুই চারি কথা না বলিয়াও থাকিতে পারিতেছি না।

বিজ্ঞানের দিক হইতে জগতের মহাসভায় ভারতের স্বর্ণসিংহাসন সুপ্রতিষ্ঠিত করিবার অধিকার যে সকল ভারতবাসী মহাপুরুষ লাভ করিয়াছেন তন্মধ্যে ডাঃ সার প্রফুল্লচন্দ্র রায় বোধ হয় সর্ব্বপ্রথম—সর্ব্বপ্রথম না হইলেও একজন যে অগ্রণী তদ্বিষয়ে কোনই সন্দেহ নাই। ডাঃ রায় যখন Nitrite of Mercury প্রথম আবিষ্কার করেন, তখন তিনি ভারতবাসী হইয়া দেশে বিদেশে, প্রাচ্যে ও পাশ্চাত্যে যে সম্মান লাভ করিয়াছিলেন সেই সম্মানসূচক জয়ধ্বনিতে আমার ন্যায় অবৈজ্ঞানিকেরও বক্ষ উৎসাহ ও আনন্দে বিস্ফারিত হইয়া উঠিয়াছিল। এই সূত্রে তাঁহার প্রতি যে শ্রদ্ধা আমার অন্তরে জাগিয়া উঠিয়াছিল, তাঁহার প্রণীত হিন্দু রসায়নের ইতিহাস পড়িয়া তাহা আরও দৃঢ়তর হইয়াছিল। পাশ্চাত্য বিজ্ঞানের মধ্যে লালিতপালিত হইয়া একজন বাঙ্গালী যে দেশীয় রসায়ন বিজ্ঞানের প্রতি বিশেষ শ্রদ্ধাবান হইতে পারেন, এরূপ ধারণা আমার পূর্ব্বে ছিল না। তিনি বাঙ্গালীর দাস মনোভাব ছিন্ন করিয়া কেবল নিজেই যে জ্ঞানবিষয়ে মুক্তির আস্বাদ পাইয়া নিশ্চিন্ত হইয়া বসিয়া ছিলেন তাহা নহে, শত শত ভারতবাসীর সম্মুখে সেই মুক্তির রাজপথ উন্মুক্ত করিয়া এক নবতর আশার সুমঙ্গল বায়ু প্রবাহিত করিবার চেষ্টায় প্রাণপাত করিতে কৃতসঙ্কল্প হইলেন। তাঁহারই সেই প্রাণপণ প্রচেষ্টার ফলে আজ আমরা কত ভারতবাসীকে বিজ্ঞানবিষয়ক শ্রেষ্ঠতালাভের দিকে অগ্রসর হইতে দেখিতেছি।

কিমিয়াবিদ্যা (Chemistry) সম্বন্ধীয় গবেষণা ও আলোচনায় কি প্রকার মনঃপ্রাণ ঢালিয়া দিতে হয় আচার্য্য প্রফুল্লচন্দ্রই নিজের জীবন ও উপদেশের ভিতর দিয়া তাহার আদর্শ ভারতবাসীর সম্মুখে সর্ব্বপ্রথম ধারণ করিলেন এবং তাঁহার ছাত্রবর্গের অন্তরে সেই ভাব সম্যক উদ্বুদ্ধ করিয়া তুলিলেন। তাঁহার প্রেরণা তাঁহার ছাত্রবর্গকে যে কিরূপ অনুপ্রাণিত করিয়াছে, তাহার অনেক উজ্জ্বল দৃষ্টান্ত আমাদের প্রত্যক্ষ হইয়াছে।

রসায়নকে কেবল পুঁথিগত তত্ত্বহিসাবে তিনি দেখিতেন না, কিন্তু

বিজ্ঞানের এই অংশকে কিরূপে দেশের উন্নতি ও মঙ্গলসাধনে প্রয়োগ করা যাইতে পারে তাহাই এই দেশসেবক নীরব কর্ম্মীর একান্ত ধ্যানের বিষয় ছিল। মঙ্গলময় ভগবান তাঁহার একনিষ্ঠ স্বদেশপ্রেমসাধনে এক সুন্দর সুযোগ ও অবসর প্রদান করিলেন। Bengal Chemical & Pharmaceutical Works যখন নির্ব্বাণপ্রায় হইয়া যাইতেছিল, তখন ডাঃ রায়ই উহার কর্ণধার হইয়া ব্যবহারিক বিজ্ঞানের মৃতসঞ্জীবনী শক্তিতে উহাকে কেবল সঞ্জীবিত করিয়া তুলেন নাই, বলিতে গেলে এই প্রতিষ্ঠানটীকে সমস্ত ভারতের মধ্যে অন্যতম শক্তিমান রাসায়নিক প্রতিষ্ঠানরূপে দাঁড় করাইতে সমর্থ হইয়াছেন। তাঁহার সকল কার্য্যেরই মূল প্রবর্ত্তক স্বদেশপ্রেম। সেই স্বদেশপ্রেমই তাঁহাকে এত বড় প্রতিষ্ঠানের বলিতে গেলে একচ্ছত্রী ভারগ্রহণে অকুতোভয়ে প্রবৃত্ত করিয়াছিল। তিনি কেবল রসায়নবিৎ বৈজ্ঞানিক পণ্ডিত ছিলেন না, কিন্তু তিনি যে কিরূপ কর্ম্মকুশল ও practical লোক ছিলেন, এই বৃহৎ প্রতিষ্ঠানটী ১৮৯২ খৃষ্টাব্দে প্রতিষ্ঠিত করিয়া একাদিক্রমে আজ চল্লিশ বৎসর যাবৎ ইহার কর্ণধারস্বরূপে উহার সকল বিভাগে যথাযুক্ত কর্ম্মের ও সুশৃঙ্খল পরিচালনার ব্যবস্থা করিয়া আসিতেছেন, তাহাতেই সম্যক প্রকাশ পাইয়াছে। তিনি প্রাণমন ঢালিয়া ইহার পরিচালনায় দক্ষিণ হস্ত বিস্তার না করিলে বঙ্গের গৌরব তথা ভারতের গর্ব্বস্থল এই প্রতিষ্ঠানটীকে আমরা দেখিতে পাইতাম কিনা সন্দেহ।

তাঁহার কর্ম্মকুশলতা আশ্চর্য্য, তিনি দেশের ভাল বলিয়া যাহা মনে করিতেন তাহার সফলতাসাধনে সমস্ত হৃদয়মন ঢালিয়া দিতেন—নিরলস হইয়া তাহাকে কৃতকার্য্যতার অভিমুখে পরিচালিত করিতে সচেষ্ট হইতেন এবং সেই কারণে তাঁহার কর্ম্মকুশলতাও পরিব্যাপ্ত হইয়া পড়িত; ইহার দৃষ্টান্ত আমরা তাঁহার খদ্দরপ্রচারকার্য্যেই প্রত্যক্ষ করিতেছি। তিনি মহাত্মা গান্ধীর সহিত এক মতে বুঝিয়াছেন যে, খদ্দরের বহুল প্রচারই দেশের সর্ব্বাঙ্গীণ স্বাধীনতা ও উন্নতি আনয়নের প্রধানতম উপায়, এই কারণে খদ্দর-প্রচারকার্য্যে তিনি যে কিরূপ প্রাণপণ পরিশ্রম করিতেছেন, তাহা আমাদের সকলেরই প্রত্যক্ষ হইতেছে। এই সূত্রে তিনি বেঙ্গল কেমিকেলের ন্যায় খাদি প্রতিষ্ঠানেরও অন্যতম সুদৃঢ় স্তম্ভরূপে দাঁড়াইয়া আছেন, এই কার্য্যে তিনি অকাতরে মুক্তহস্তে অর্থব্যয় করিতেও পশ্চাদপদ হন নাই।

স্বদেশপ্রেম কিরূপ তাঁহার মর্ম্মে মর্ম্মে বিজড়িত তাহার ইঙ্গিত আমরা

উপরে দিয়া আসিয়াছি। তিনি যখন দেখিলেন যে, তাঁহার দেশবাসিগণ স্বাধীন জীবিকার অভাবে অন্ন সংস্থানের জন্য একমাত্র চাকরীর সন্ধানে ঘুরিতেছে, তখন তাঁহার কোমল হৃদয় কাঁদিয়া উঠিল এবং তিনি উহার প্রতিকারের উপায় উদ্ভাবনে প্রবৃত্ত হইলেন। তিনি কেবল তত্ত্বহিসাবে নহে, কিন্তু ব্যবহারিক রসায়নবিজ্ঞান শিক্ষা দিয়া শত শত ছাত্রকে দেশের মধ্যে ছাড়িয়া দিলেন। সেই সকল ছাত্র স্বাধীন জীবিকার উপযোগী নব নব প্রতিষ্ঠানসমূহ স্থাপনে অগ্রসর হইলেন। ইহা বোধ হয় অস্বীকার করা যায় না যে, আজ স্বদেশীয় সাবান প্রভৃতির যে সকল কারখানা স্থাপিত দেখিতেছি, আচার্য্য প্রফুল্লচন্দ্র এবং তাঁহার উদ্যম ও উৎসাহশীল ছাত্রবর্গের প্রত্যক্ষ বা পরোক্ষ সংস্পর্শই সেই সকলের মূল উৎস।

উপসংহারে আমি ভগবানের নিকট আচার্য্য প্রফুল্লচন্দ্রের দীর্ঘজীবন প্রার্থনা করি এবং তাঁহার নিকট এই আশীর্ব্বাদ ভিক্ষা করি যে, আমার স্বদেশবাসিগণ আচার্য্য প্রফুল্লচন্দ্রের পদাঙ্ক অনুসরণ করিয়া রসায়ন প্রভৃতি মঙ্গলপ্রসূ বিজ্ঞানসমূহ যেন আয়ত্ত করেন এবং সেগুলির ব্যবহারিক প্রয়োগ দ্বারা স্বাধীন জীবিকার পথসকল উন্মুক্ত করিবার শক্তি লাভ করেন। স্বদেশবাসিগণ পরস্পরকে অকৃত্রিম সখ্যবন্ধনে আবদ্ধ করুন এবং পরস্পরের প্রতি আন্তরিক বিশ্বাস স্থাপন করিয়া স্বাধীন জীবিকার প্রতিষ্ঠানসমূহকে সাফল্যমণ্ডিত করিয়া তুলুন। এইরূপ করিলেই প্রফুল্লচন্দ্রের জয়জয়কার হইবে এবং ভারতমাতা নবতর উজ্জ্বল মুখশ্রী ধারণ করিবেন। তখনই দেশবাসিগণের মস্তকে ভগবানের মঙ্গল আশীর্ব্বাদ শ্রাবণের বারিধারার ন্যায় বর্ষিত হইবে।

সংগচ্ছধ্বং সংবদধ্বং সংবোমনাংসি জানতাম্—সমপ্রাণে অগ্রসর হও, সমপ্রাণে কথা বল এবং তোমাদের হৃদয় সখ্যসূত্রে আবদ্ধ হউক।

শ্রীক্ষিতীন্দ্রনাথ ঠাকুর

The Role of Aquatic Vegetation in the Biology of Indian Waters

By Kalipada Biswas (Calcutta).

(Plates III-XI).

"Nature hath tones of magic deep, and colours iris bright,
And murmurs full of earnest truth, and visions of delight:
'Tis said, 'The heart that trusts in her was never yet beguiled,'
But meek and lowly thou must be and docile as a child.
Then study her with reverence high, and she will give the key,
So shalt thou learn to comprehend the 'secrets of the sea'."

MARIE J. EWEN.

Water is the sustainer of life. Creation proceeded from water, so say the sacred books of India. About three-fourths of the globe are water and many "unfathomed caves of ocean bear" numerous plant and animal organisms which originate, grow and die in the depths of the seas, and finally the remains of many of them are preserved for ages as fossils. Thus in some of the beds of the oceans have been discovered vast areas covered with deposit of fossil remains of the most remarkable unicellular alga known as *Diatom,* a large number of which is the denizen of salt water. The *Diatoms* are of various fantastic shapes. They are mostly brown in colour. The cell walls are silicified and characterised by sculptures of extraordinary beauty. They occur in great abundance displaying movements of various kinds, and serve as one of the most important food materials for the smaller members of the aquatic fauna. These *Diatoms,* with other algae, act as great purifying agents by supplying oxygen and absorbing carbon dioxide, which animal respiration and decomposition impart to the water. The *Diatoms*

are ubiquitous species occurring in lakes, ponds, ditches and other fresh water reservoirs. They reproduce both by asexual and sexual methods which have not yet been fully investigated. India has vast coast lines and climates ranging from the most cool to the most hot, being suitable for harbouring a fairly large *Diatom* flora of which only about 3% of the probable species have been worked out up to the present time.

The bulk of the vegetation of the sea of which the *Diatoms* are only the unicellular forms, is composed of seaweeds. They are indeed the "treasures of the deep." These seaweeds exhibit marvellous display of colours in their fronds, and the classification is, therefore, mainly based on the variation in their colour. Hence they are divided into Blue-green (*Myxophyceae*), Green (*Chlorophyceae*), Brown (*Phoephyceae*), and Red (*Rhodophyceae*). Some of the members of the *Rhodophyceae* attain enormous size, of which *Macrocystis pyrifera* and *Laminaria cloustoni* are the well-known examples. Some of the members of the *Rhodophyceae* are freshwater species, and of these *Batrachospermum vagum*, *Sirodotia species*, *Compsopogon coeruleus* and *Compsopogon lividus* have been recorded by the author in recent years. The blue-green and green algae have a large number of representatives in freshwater too, which will be mentioned hereafter. The reproduction of the seaweeds is a very complicated process and much light requires to be thrown on this subject. But investigations in recent years have revealed many interesting facts which prove that the sexual reproduction has attained in the seaweeds a great advancement both from the morphological and the cytological standpoints. The seaweeds of the different classes mentioned above are mostly submerged, and are attached by a holdfast, a root-like structure, called rhizoids, in lower plants. Of the phanerogamic plants only a few are residents of the sea. The seagrass *Zostera marina* (eel-grass) is the most predominant species worth mentioning. The seaweeds are the important sources of Iodine.

The colour of the seawater which is sometimes red, brown, greenish grey, blue-green, etc., is due to the presence of large masses of floating plant and animal organisms drifted by the current

of the sea and wind. Such a floating mass of organisms is known as *Plankton* and here we are concerned with only the marine *Micro-phyto-plankton*. These are generally composed of *Cyanophyceae*, *Diatomaceae* and *Peridineae* (*Dino-flagellatae*). Thus *Trichodesmium erythraeum* imparts, by its occurrence in great abundance, the red colour to the water of the Red Sea, especially near the coast. *Nodularia spumigena* causes greenish grey colour, due to its presence in myriads, in the Baltic Sea; so does *Heliotrichum* in the tropical parts of the Atlantic Ocean. Some of the species of the *Diatomacious* genera: *Thalassiosira*, *Chaetoceras*, *Rhizosolenia*, *Coscinodiscus* and *Thalassiothrix*, floating in huge masses, lend brownish or greenish tints to the Arctic seas. Of the flagellata *Ceratium tripos* is the well-known marine species, and the luminiferous plankton forms of the marine *dino-flagellates* in the North Sea, Skager-Rak and Western Baltic render the seawater phosphorescent in the autumn. The marine plankton algae are the source of food to marine zooplankton which is the ultimate food of other larger marine animals, such as sea gulls, whales and others. The majority of the food supply is in the form of fat. The abundance of oil in marine animals is perhaps due to plant food full of oily substance. The distribution of the plankton algae, as also the occurrence of large seaweeds in different parts of the seas at different strata are controlled by various climatic and physico-chemical factors dependent on geological conditions.

In the brackish waters of the inland gulfs, bays, lakes (as for example the Chilka Lake and the Ennur Salt Lakes), and also channels and creeks in this country, the aquatic vegetation is interesting in the sense, that towards the land the freshwater species show signs of halophytic (salt water plants) adaptations by gradually encroaching upon the brackish water areas. Like the typical members of the mangrove formation in the estuarian regions, the water plants in these situations have also their representatives which are to a certain extent characteristic of littoral flora. The nature of these mangroves, especially algal vegetation has been discussed in brief by the author in his previous papers on the Calcutta Salt Lakes and the Chilka Lake.

The most common species of algae found in these parts are *Enteromorpha intestinalis*, *Enteromorpha prolifera*, *Enteromorpha compressa*, *Chaetomorpha linum*, *Cladophora glomerata*, *Cladophora crispata*, *Cladophora calicoma* and several typical species of *Oscillatoria*, *Lyngbya* and *Microcoleus*, of which *Oscillatoria laetevirens*, *Lyngbya aestuarii* and *Microcoleus chthonoplastes* and others deserve special mention. *Lyngbya ochracea*, the iron bacterium forms here and there rusty colouration along the margin. Several species of brackish water and salt water *Diatoms* form thin film on the silt along the banks after the flood-tide subsides. Other species are members of *Rhodophyceae* and *Phaeophyceae*. Of the *Rhodophyceae-Gracilaria confervoides* (one of the species from which Agar Agar is manufactured), *Grateloupia filicina*, *Polysiphonia* sp., *Ceramium gracillimum* and others are common in the Chilka Lake and the Ennur Salt Lakes. Towards the sloping margins in shallow portions of these brackish water lakes are

Fig. 1.—A corner of Prain Lake, Royal Botanic Garden, Calcutta, showing in the foreground near the side growth of *Nelumbium speciosum*, *Nymphaea alba* and *Nymphaea rubra*, *Salvinia cuculata*, *Azolla pinnata* and *Marsilea quadrifoliata*. In the background patches of amphibious plants *Panicum muticum* and *Herpestris monniera* are visible. Photo by Mr. T. D. Srinivasan.

sometimes found submerged, *Halophila ovata* and *Potamogeton pectinatus*.

The current waters of rivers, streams and waterfalls etc., do not harbour sufficient vegetation which might be said to exert much influence on the biological conditions prevailing in them. In the river Hooghly near the Royal Botanic Garden, Calcutta, some of the common species of algae found are: *Lyngbya aestuarii*, *Enteromorpha* sp., and *Diatoms*. Of the *Diatoms*, *Synedra affinis* var. *fasciculata*, *Melosira varians* and *Melosira Dickii* are the common epiphytic *Diatoms* which adorn the filamentous algae growing on different substrata along the banks. Of *Rhodphyceae*, *Chylocladia kaliformis* with its full splendour has also been dis-

Fig. 2.—A choked up tank of the Royal Botanic Garden, Calcutta, with the surface vegetation of *Panicum muticum* and *Mikania scandens* over the Macro-plankton flora of *Eichhornia speciosa*. Photo by Mr. T. D. Srinivasan.

covered by the author growing frequently on bricks, stones, irons and wooden structures between tide marks, and here reported for the first time from India. Species of *Polysiphonia* too are sometimes found attached to the iron and wooden structures of the floating portion of the jetty and on stones and bricks strewn along the margin of the river. Vessels calling at the port of Calcutta,

the ferry boats and the buoys are sometimes seen covered, particulary in the zone of tide marks, with beautiful green *Enteromorpha* sp., *Polysiphonia* sp., *Lyngbya aestuarii* and other blue-green algae. *Lyngbya ochracia*, the iron bacterium, and the deep water marine species of *Diatom*, *Coscinodiscus radiatus* are not rarely found in the plankton collection of this river. The latter species perhaps found its access into the river drifted from the sea by high tide. This *Diatom* has recently been collected by Lt.-Col. R. B. Seymour Sewell, Director, Zoological Survey of India, at a depth of about 700 fathoms during his oceanographic survey in the Indian Ocean. Of the algae of the waterfalls *Batrachospermum* species, *Sirodotia* species—the two fresh water species of *Rhodophyceae* are common. Recently the author has discovered a new species of *Sirodotia* collected from the bed of a streamlet in the hills of Tenasserim, Mergui, South Burma. These two algae growing on rocks and pebbles forming the beds of waterfalls and rapid hill streams are adapted to the strong currents of water flowing sometimes at a tremendous speed. Of the Phanerogams the species of *Podostemon* are frequently met with in similar habitats in the rapid current of the hill streams, cascades and waterfalls. Of the several Indian species of this genus, *Podostemon Wallichii* is the most common. The lithophilous (rock-loving) plant shows extraordinary adaptations to its peculiar environments. The chief factor against the growth of the plants in the rapid waters of hill streams, waterfalls and near the mouth of rivers is the want of photic factor, i.e., absence of sufficient light in the water due to the presence of large amount of suspended impurities. Moreover, the rapid current does not allow fruits, seeds and spores to settle down. In some cases near the sea the salinity also goes against plant growth. The rivers, streams, etc., however, play an importnat part in the migration of the plants by carrying along with the current of water, bulbs, fruits, seeds, spores, etc., to different parts which under favourable conditions grow again. The plants thus distributed by water are known to botanists as 'Hydrochores.' The hot springs hardly sustain animal or plant life on

account of the high temperature of the water. But *Oscillatorias, Lyngbyas, Diatoms* and *Iron bacteria* have been collected by the writer from the edges and the beds of some of the hot springs in different parts of this country.

Let us now pass on to the freshwater plants which are so plentiful in this country. Anyone, even a casual rambler, walking along the banks of a lake, a jhil, a tank, a pond, or a puddle, and observing plants and animals floating, swaying, dancing and playing in the water in their natural beauty, cannot but wonder at the marvels of pond-life, and will find in them "complete expression of the will of God in things created." He will then surely try to peep into the secrets of "organic creation in the midst of which our lives are embedded."

In a lake such as the Loktak in the Manipur, Assam, or a stagnant jhil, tank, pond, etc., harbouring acquatic plants, several zones of vegetation can easily be distinguished. In this country, there is a more or less uniformity in the mode of growth of aquatic plants in a water reservoir. The vegetation may vary only in details, number of individuals, luxuriance and specific representation, according to the climatic and edaphic factors prevailing in a particular locality. The investigation of periodicity and distribution of these tires of vegetation in relation to the nutrients, temperature, light intensity, permeability and various other factors, has recently engaged the attention of the biologists all over the world. I shall record here some of my observations on the interrelations of these different associations of vegetation mainly from floristic aspect.

The common plant that we notice in tanks everywhere is *Vallisneria spiralis* a submerged acquatic plant, rooted at the bottom, with long ribbon-shaped green leaves. *V. spiralis* very frequently goes down to a considerable depth of water, and sometimes forms at the bottom more or less a pure association. This plant is dioecious, i.e., male and female flowers are born on two separate individuals. Towards the end of the cold weather, from February to April, the female plant shoots out a long threadlike stalk bearing at its apex the stigma or female

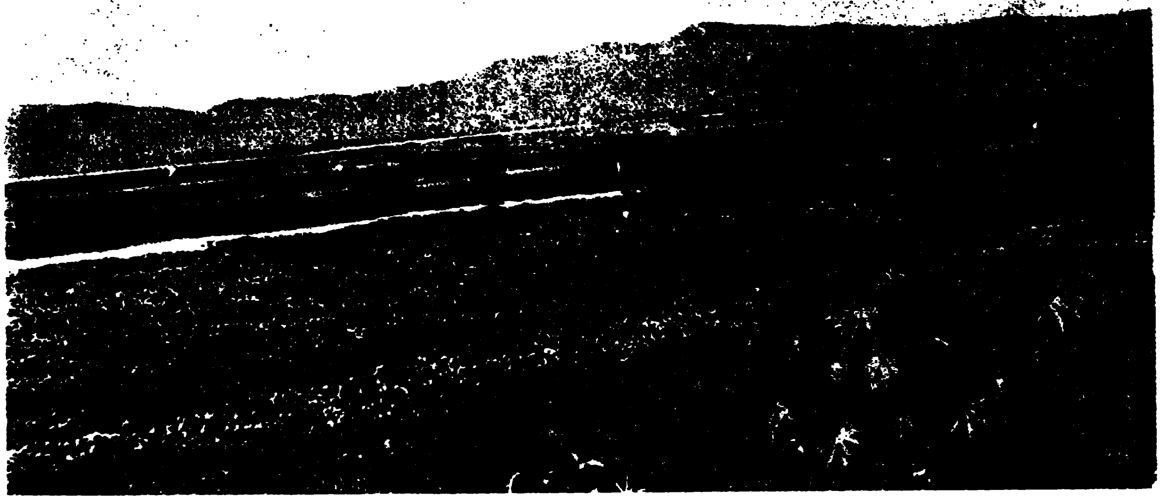

Fig. 3.—Lotak Lake, Manipur, Assam. In the foreground is the surface vegetation of the mixed association of *Eichhornia speciosa*, *Oriza sativa* and *Polygonum orientale*. In the background are the floating islands of vegetation composed of the species *Polygonum orientale* and *Oriza sativa* (wild rice) stretching up to the hills. In the narrow open spaces, through which country boats pass, are found lower members of the Macro-plankton flora consisting of *Ricciocarpus natans*, *Azolla pinnata*, *Salvinia natans* and submerged *Utricularia flexuosa*, *Ceratophyllum demersum* and *Hydrilla verticillata* harbouring rich algal flora. On the right hand corner are a few shrubs of *Ricinus communis* (castor oil plant), cultivated along the margin of the lake by the fishermen residing in the hamlets of these localities. Photo taken by the writer during his botanical exploration in the Naga Hills and Manipur in 1930.

receptive spot. The male flowers coming out of the sheath at the base of the plants are found floating in the water in large masses. The male germ then reaches the female organ and fertilisation takes place resulting in seeds. Species of *Blyxa*, characterised by similar long ribbon-shaped leaves, forms not rarely important bottom vegetation of jhils, khals, etc. These *Blyxa* species seem to prefer silghtly brackish water. Associated with these are not infrequently found *Ottelia alismoides*, a similarly rooted plant with leaves having a long stalk and cordate or subcordate broadly elleptic lamina. It bears a single white flower at the end of a long pedicel developing from the root-stock (stem) fixed in the muddy bed. Along the edges of the tanks, jhils, etc., associations of *Polygonum glabrum*, *P. orientale*, *Colocasia antiquorum*, swamp-reeds and grasses especially *Scirpus* sp., (*Scirpus articulatus*) *Eleocharis plantaginea* and others are common features. In some of the lakes, ponds and tanks the species of the interesting algal genera *Chara*, *Nitella* and *Tolypella* form, up to a certain depth towards the sloping side on loose muddy soil, a carpet like association. In the hot months before the rains they fruit and in autumn renew their life history. Of the rooted water fern mention may be made of *Isoetes* sp., growing sometimes in association with the members of *Characeae*. These associations along with other rooted aquatics growing on loose muddy soil of the lakes, jhils, tanks and ponds may very well be compared with the "Limnaea-formation of Benthos of loose soil." The other rooted submerged plants are species of the genera: *Potamogeton*; *Aponogeton*; members of *Nymphaeaceae* :—*Nymphaea*, (*Nymphaea* lotus, *N. rubra*, *N. stellata*); *Euryale*, (*Euryale ferox*); *Nelumbium*, (*N. speciosum*); *Limnanthemum*, (*L. cristatum*, *L. indicum*). Most of these are characterised by leaves with very long stalks and large round blades which float on the surface of water. These leaves generally come out of the stem which are the creeping rhizomes embedded in the mud at the bottom of tanks, lakes, ponds, etc. The flowers of these rooted aquatics borne on long flowering shoots are lifted above the water and open out in the air. These submerged plants, as a

rule, are perennial and display a gregarious habit of growth. They absorb food materials from the soil at the beds of water reservoirs more or less like those of the terrestrial plants; but differ, as usual with aquatic plants, in morphological, anatomical and physiological details; such as development of heterophylly, dearth of mechanical tissues, soft and pliable petiole, abundance of large air chambers, development of anthocyanin in the leaves and roots and so on. These modified characters, unlike land plants, are due to the aquatic environments. The rooted water plants reproduce both by their root stocks (rhizomes) and seeds. The rooted aquatics mentioned above do not generally cause choking up of fairly deeper tanks, jhils and ponds, but in shallow pools and puddles having thick deposit of loose mud and silt, the *Nymphaeas, Nelumbiums and Euryale ferox* play considerable part in covering up the surface of water with their broad leaf lamina especially before and after the rains.

Apart from this bottom vegetation of larger aquatic Phanerogams there is, on the muddy floor of tanks etc., a thin film of micro-organisms, composed of *Diatoms*, blue-green algae (*Schizomycetes*) and other allied vegetation of bacteria forming what may be called a vital layer. These organisms are of great biological importance in disorganising the organic matters and converting them into suitable form of plant food for the taller permanently rooted aquatic plants mentioned above.

In a water reservoir, where aquatic plants are allowed to have free play one finds, other than these vital layer and zone of rooted aquatics, another zone of submerged plants which generally float in suspension under water. Of such plants the most common species of our country are *Hydrilla verticillata, Ceratophyllum demersum, Myriophyllum tuberculatum, Lagarosiphon Roxburghii, Najas indica, N. foveolata* and the insectivorous bladderworts—*Utricularia flexuosa, U. stellaris* and others. These submerged suspended aquatic plants in old lakes, tanks, etc., often develop an impenetrable network of dense vegetation in the central column of water. Some of these plants, e.g. *Utricularias*, prefer to occupy the surface layer of water. These plants, like other

water plants, propagate more rapidly by vegetative method of reproduction than by sexual method, that is by seeds which when mature drop on the mud and germinate. These plants growing from seeds are at first attached to the mud during juvenile stages of their growth, but later on they dislodge themselves from the loose muddy layer and float freely in suspension under water. The fruits of *Ceratophyllum demersum* are, like those of *Trapa bispinosa* and *T. natans* (*Panifal*), furnished with three spinules at the three corners. When they fall in the mud, they stick on to the soil and are not easily shifted by the movement of the water below. During January and February and sometimes in March too, these plants flower and fruit and seeds are available from July to September and October. During the cold season *Utricularias, Hydrilla verticillata, Ceratophyllum demersum* and other submerged aquatic plants develop vegetatively by another kind of winter buds knows as "hibernacula" or "squamulae intravaginales," which also grow out into new plants, thus tiding over the unfavourable season. These plants depend for their growth mostly upon the nutrient salts dissolved in the water. But their occurrence in the middle zone deprive the rooted water plants below much of their light and oxygen. The floating submerged acquatics harbour many epiphytic algae, especially *Conjgatae,* (*Desmids*), *Oedogoniales, Ulotrichales, Diatoms, Characium* and colonial members of *Chlorococcales* and *Cyanophyceae,* such as species of *Scenedesmus, Pediastrum, Coelastrum, Ankistrodesmus, Oocystis,* species of the family of *Chroococaceae, Chamaesiphonaceae, Oscillatoriaceae, Rivulariaceae, Scytonemataceae* and others, some of which have been noted in the paper on the Algae of the Loktak lake by Dr. Bruhl and the author. The materials of this paper had been collected mostly from the aquatic vegetation of the Loktak lake chiefly composed of: *Ricciocarpus natans, Azolla pinnata, Salvinia natans* and *Utricularia flexuosa* floating on the surface; and *Hydrilla verticillata* and *Ceratophyllum demersum,* sometime associated with *Trapa natans,* occupying the middle zone of the lake.

The suspended mass of vegetation gradually leads to a denser

surface vegetation, partly due to the stagnation of the water and partly to the supply of rich plant food in the form of dissolved salts. The conversion of rotten vegetation and other organic matters into nutrient salts is entirely due to the activity of the putrefying bacteria and *Schizomycetes* of the vital layer at the bottom, where older portions of the vegetation and other organic matters continuously settle down. There is thus a cycle of biological actions and reactions by which a lake, tank and pond are supplied with an inexhaustible store of food materials for the growth of plant. In such tanks there is frequently met with not only a rich Macro-phyto-plankton (Macro-plankton is composed of a plankton flora whose members are visible to the naked eye) but also amphibious plants. By amphibious plants here are meant marsh plants or those terrestrial plants which grow on moist soils along the edges of tanks and adapt themselves easily to aquatic conidtions. The Macro-phyto-plankton of our country is mainly composed of the representatives of the family of *Lemnaceae*, of which *Wolffia arrhiza* is a very minute gregarious plant floating in water as green granules. Of similar habit is *Lemna polyrrhiza, L. paucicostata* and *L. trisulca*, which are characterised by their small, round or oval flat leaf-like shoots. The aracious *Pistia Stratiotes* and pontederiacious *Eichhornia speciosa* (the water-hyacinth) are larger members of the Phanerogamic Macro-plankton flora. The others belong to *Hydropterideae* (the water-ferns), of which the rootless *Salvinia natans, S. cucullata* and *Azolla pinnata* are quite common everywhere. The largest fern associated with dense growth of aquatic Macro-plankton flora is the beautiful *Ceratopteris thalictroides*. A floating liverwort *Ricciocarpus natans* recorded by S. R. Kashyap from the Dal Lake, Kashmir can also be reported here from the Loktak Lake. The Macro-plakton formation may be composed of one or several association, either mixed or pure. Such an association constituting a dominant species is distinguished as *Eichhornia* association, *Salvinia* association, *Lemna* association, *Azolla* association, *Wolffia* association and so on. A plant community constituting these associations is termed as 'Hydrocharid' formation or 'Pleuston.' Macro-plankton is synonymous to Warming's Mega-plankton. The

members of Mega-plankton, such as *Eichhornia, Lemna, Wolffia* and others are perennial and gregarious in their habit and this is due to their rapid vegetative growth. In most of these genera sexual reproduction is inhibited or almost ceases. Seeds of *Eichhornia speciosa* and sporocarps of *Salvinia cucculata* and *S. natans* are, therefore, so very scarce.

Rich Macro-plankton flora by their enormous numbers choke up the surface of a tank, pond, jhil, etc., and in this manner helps the spread of amphibious plants, and we see very frequently the water-fern, *Marsilea quadrifoliata,* creeping into the mat of Macro-plankton flora. The amphibious Phanerogams commonly spreading over the Hydrocharid formation of a stagnant lake, jhil or tank are *Ipomoea reptans, Jussiaea repens, Polygonum orientale, Neptunia oleracea, Herpestis Monnieria, Colocasia antiquorum, Oenanthe bengalensis* and grasses such as *Hygrorhiza aristata, Leersia hexandra, Panicum muticum, Oriza sativa* (wild rice) and *Panicum flavescens* and others. *Panicum muticum* is a native of Africa but was introduced in 1845 and is now wild in this country in ponds and ditches and marshy lands. It is not infrequently used as fodder grass. *Panicum flavescens* is a terrestrial grass introduced from Mauritius, but is now growing everywhere during the rains. Sometimes even ordinary climbers, such as the American weed *Mikania scandens,* and the climbing fern *Lygodium japonicum* and similar creepers and other trailers are found extending over the mass of surface vegetation. In the Loktak Lake, *Polygonum orientale* and *Oryza sativa* association, with their roots and stems interlocked by submerged plants, form the so-called "floating islands" of vegetation as described by the late Dr. N. Annandale, F.R.S. Sometimes *Trapa bispinosa* and *Trapa natans,* the *"singara"* plant aid in developing a more denser and firmer congestion.

The American plant *Eichhornia speciosa* demands special mention for its invasion of tanks, ponds, and pools, etc. This plant encroaching upon rice fields and waterways in recent years has proved to be a serious menace destroying the economic resources of our country. Its rapid reproduction vegetatively from the rhizome by means of effsets and also from seeds, as recently

discovered by Dr. P. Bruhl, Prof. P. Parija and Dr. Agharkar, makes the question more complicated for eradication. Its spread even in the Loktak Lake, choking up nearly the whole area, across the barrier of Naga Hill ranges can only be explained by the fact that it must have either been distributed there by human agency or by water birds. The water birds wading through and flying over the rice fields of Sylhet cross the valleys and the cultivated terraced hill slopes of the Naga Hills, and finally find their access into the Loktak Lake. The birds evidently carry under their wings light seeds of water hyacinth. These seeds under favourable conditions of the lake germinated, and by the rapid vegetative growth soon gained its supremacy over the indigenous flora of the lake.

In some of the jhils, tanks, ponds, etc., which have not been invaded by dense mass of Mega-plankton flora, another kind of plankton formation consisting of filamentous algae is commonly seen. These algae are particularly predominant during spring and especially the hot months before the rains. In this period, due to the activity of the reproductive process, energy is liberated, resulting in the evolution of profuse gas bubbles and fragmentation of filaments. These algae, therefore, break loose from the soft muddy soil and rise to the surface owing to the entanglement of the gas bubbles in their threads. They thus float on the surface as huge frothy masses of threads giving shelter to smaller epiphitic blue-green, green and brown (*Diatom*) algae. Smaller aquatic animals, such as worms, mollusca and others find suitable food and shelter in such floating masses of algae. Somewhat similar conditions also prevail after the rains, during autumn and cold season, but not so much pronounced. This period may be considered the vegetative period of these filamentous algae, when they develop from the resting spores, akinetes, gonidia, hormogones, etc. Their activities at this time are to a greater extent confined to the bottom of the tanks, ponds, etc. Such annual development of plankton constituting tangled masses of filamentous algal vegetation forms what may be called "False plankton" known to the biologists as "Tricho-plankton." The "Tricho-plankton" of our

country is chiefly composed of *Oscillatoria princeps*, *O. tenuis*, *Lyngbya aerugineo-caerulea*, *L. majuscula*, *L. subconfervoides*, *Tribonema bombycinum*, *Cladophora glomerata*, *Cladophora crispata*, *Hydrodictyon reticulatum*, *Pithophora kewensis*, *Spirogyra nitida*, *Spirogyra maxima*, *Oedogonium laeve*, *Zygnema* sp., *Mugotia* sp. The occurrence of *Lyngbya subconfervoides*, *Tribonema bombycinum*, *Cladophora crispata* and species of *Oedogonium* in some of the tanks, ponds, and other water reservoirs for several years as floating masses suggests their capacity of perenniation.

The different zones of aquatic vegetation in a lake, jhil, tank, pond and puddle sketched above, viz., the Amphibious vegetation and the Mega-plankton flora forming the surface vegetation; the submerged suspended vegetation of the central column of water; the Limnaea formation of 'Benthos of loose soil' along the sloping margins and shallower portions; the gross rooted aquatic and the vital layer on the loose muddy bottom may graphically be represented in the following diagram (Plate XI).

I have dealt so far with the vegetation in an undisturbed lake, tank, pond, etc., overgrown with vegetation in all the strata. But in a reservoir of water where there is absence or dearth of submerged vegetation in the middle stratum, and entire absence of Macro-plankton flora another type of plankton flora is commonly present. The members of this plankton flora is visible under the microscope and cannot be easily seen with the naked eye. Such a plankton formation is Micro-phyto-plankton. Predominance of Micro-phyto-plankton is thus observed in tanks, ponds, etc., which have clean open surface. It is particularly abundant where there is a sparse bottom vegetation of rooted aquatics and nearly entire absence of suspended submerged water plants. The Micro-phyto-plankton are chiefly composed of unicellular and colonial types of blue-green and green algae. The *Diatoms* also play an important part. Investigation of the periodicity of the Indian Limnoplankton (freshwater plankton) flora has very little been attempted. A very brief account of the results of my investigations may not be out of place here. For further information I refer the reader to my papers

on algological researches especially the series started in the *Revue algologique* under the heading "Census of Indian Algae."

The Micro-phyto-plankton of this warm country is not fundamentally different from those of the other warmer parts of the world. Of the representatives of the Micro-phyto-plankton, the blue-green alga *Clathrocystis aeruginosa* is the most dominant species found all over the Indian Empire in lakes, tanks, pools and other water reservoirs floating in great abundance as minute blue-green granules. This alga is not infrequently mixed up with other panklton species of *Cyanophyceae*, such as *Microcystis flosaquae*, *Anabaena flosaquae*, *A. indica*, *Spirulina major*, *S. platensis*. Sometimes species of *Cylindrospermum*, *C. doryphorum*, a new species described a few years ago by Dr. Bruhl and the writer, has been observed in the beginning to be the only species composing the Micro-phyto-plankton in a tank. Later on this species was invaded by *Clathrocystis aeruginosa* occupying mainly the surface and *C. doryphorum* floating in a lower stratum. Associated with these are sometimes found mucus nodules of *Gloetrichia pisum* and *G. natans*. These members of *Nostocaceae* are at first attached but later on found floating. The green algae, such as *Volvox aureus*, *Pandorina morum*, *Gonium pectorale*, *Chlorella vulgaris*, and zoospores of *Ulotrichales* floating in enormous numbers form either pure or mixed association. *Diatoms*: *Synedra affinis*, and its var. *fasciculata*, *S. ulna*, *Melosira sp.*, *Fragilaria sp.*, *Nitszchia sp.*, and others; *Desmids*: *Cosmarium* species, *Closterium* species, *Euastrum* species, *Xanthidium* species, *Staurastrum* species; *Scenedesmus*: *Scenedesmus quadricaüda*, *S. prismticus*, *S. brasiliensis*, *S. obtusus*, *S. acuminatus*; *Pediastrum*: *Pediastrum tetras*, *P. duplex*, with its var. *clathratum*; *Coelstrum cambricum*; *Ankistrodismus falcatus* and others, are the common constituents of Micro-plankton flora. Both the unicellular and colonial members of the Micro-phyto-plankton exhibit various peculiar adaptations for the purpose of floatation, locomotion and absorption of food materials. Mixed with these green algae are also found *ciliated* representatives of unicellular green algae

Dinoflagallata. Of the *Flagellates*, *Euglena* is the most common in the lakes, tanks, and particularly in smaller pools and puddles where the water is rich in organic matters. It is this organism that forms the thin green film on the surface of water so commonly seen in smaller water reservoirs especially before the rains during hot weather. The *Euglena* species commonly met with is, like others, very sensitive to light and friction. Due to the variation in intensity of light the *Euglenas* change their colour from green to brownish red. The green film— referred to above— composed of *Euglena* species (*E. viridis*) is converted into red film due to the difference in degrees of luminosity in the Sun's rays. Slight agitation, even the impact of the rain water, induces them to form cysts and sink down. During unfavourable conditions they pass a dormant life in cysted stage. Along with them and other green algae are frequently found *Ceratium* species, *Phacus* species and the iron protozoon *Arcella*. It may be mentioned, however, that of the green and blue-green Micro-phyto-plankton, the blue-green algae and *Euglenas* are more prevalent in this country due evidently to the abundance of organic contents in the waters. The blue-green algae also gain upper hand in the struggle for existence and soon replace the green ones, if they happen to invade a tank or pool already inhabited by green Micro-phyto-plankton. The green Micro-phyto-plankton commonly appears after the rains in autumn, and the blue-green occurs in greater profusion in spring and during hot months before or sometimes during the rains as well. But during the rainy season it has been observed that sometimes, owing to the ingress of silt-laden water in tanks, jhils, ponds, etc., spattering of the drops of rain or congestion of a large quantity of plankton algae in a small area, this plankton flora dies and decomposition sets in due to the activity of the putrefaction bacteria. This results in the effusion of an unpleasant vegetable odour which is indeed very offensive when present in the water used for drinking and other household purposes. The Micro-plankton algae by their presence in great abundance imparts a definite blue-green, green and brownish red colour to an expanse of water which often attracts our attention. They are, therefore,

generally known as the so-called "water-blooms" (water flowers). The different species of Micro-plankton flora occurring in a reservoir of water act as indicators of the different qualities of water. These aglae are, therefore, sometimes designated as "Katharob" (algae of freshwater), "Mesosaprob" (algae of contaminated water) and "Polysaprob" (algae of foul water).

The minute members of plankton algae which can pass through the meshes of a townet are further termed as Nanno-plankton. Both Micro- and Nanno-phyto-plankton algae are very common in the Calcutta filterbeds. Their rapid growth is an indication of the rich plant food dissolved in the water. Some of the members of the Micro- and Nanno-plankton appear for a very short time, and suddenly disappear lasting sometimes only for a few hours. Such algae are termed as "ephemerals" by Transeau. The periodicity and life-history of the Micro- and Nanno-plankton of filterbeds is interesting and important from economic standpoint. This might be dealt with in a subsequent paper. The water of the filterbeds are supplied from the presettling tanks. These feeding settling tanks of the filterbeds harbour a luxuriant stock of rooted aquatic and submerged vegetation nearly choking up the whole area in the manner described before. This account for the rich organic contents of the water of the filterbeds. The growth of the smaller members of Micro-phyto-plankton, as found in the filterbeds running for a few days, is interfered with by the development of filamentous algae, such as *Tribonema bombycinum, Hydrodictyon reticulatum, Cladophora crispata, Zygnema* species, *Oedogonium* species, *Spirogyra* species and others. The most dominating species of algae are: *Trebonema bombycinum, Hydrodictyon reticulatum* and *Cladophora crispata*. These algae at first grow on the beds of sand of the filterbeds, but later on dislodge from the bottom. They then gradually rise to the surface due to the pressure exerted by the gas bubbles caught up in the entanglements of their threads and form the false plankton or 'Tricho-plankton' as stated in the previous pages. Of this 'Tricho-plankton' formation when one dominant species forms more or less pure association, as frequently found in the filterbeds, they are

distinguished as a particular association of that species, such as Tribonema association or Tribonemetum, Hydrodictyonetum and Cladophoretum. Thus floating in dense masses these filamentous algae finally choke up the entire bed. This condition leads to serious damage of the beds due to fissures caused by the uplift of the algae breaking up the vital layer which is highly beneficial to filtration. The large filamentous algae of 'Tricho-plankton' harbour in its turn a huge stock of animal organisms by supplying food and shelter. Among the animal organisms *Crustacea, Mollusca, Worm* (*Nematodes*) etc., by burrowing holes in the beds of the filterbeds destroy the vital layer and seriously interfere with the action of filtration. Further their excrements and respiration disturb the biological balance of the water of the filterbeds by inhibiting the self-purificatory action of the Micro-phyto-plankton. The favourable action of the Micro-organisms of the vital layer of the filterbeds, and consequently the action of filtration is in this way considerably checked.

In stagnant lakes, ponds, etc., which harbour a rich submerged and surface vegetation the biological conditions of the water like those of chocked up filterbeds are also entirely upset. The submerged vegetation under the screen of a dense surface vegetation gradually dies in the absence of light and oxygen. They then settle down and rot at the bottom. The rooted members of the aquatic plants beneath, after mouldering to death under the double roof of surface and suspended vegetation, gradually decompose. The Micro-plankton, and in some cases the smaller members of Macro-plankton flora, are eliminated at the very outset, as they are unable to cope with the rapid growth of the larger members of Mega-plankton flora and amphibious plants forming the surface vegetation. The water of such tanks and pools, thus devoid of light and oxygen, becomes surcharged with the excess of humic acid, carbonic acid and other injurious productions of putrefaction bacteria, such as ammonia, sulphuretted hydrogen, acetic acid, peptone and other various compounds of complicated structure. The colour of the water of such tanks, ponds, etc., appears dark brown due to rich humus contents. Such unhealthy

condition of water is detrimental to all freshwater fauna. Consequently the edible fauna with others soon disappear for want of food materials in the form of lower members of the animal kingdom such as *Cyclops, Copepods, Rotifers, Paramycium, Amoeba* and various others living on the Micro-phyto-plankton. Their absence in such foul water is partly due to want of oxygen, illumination and insanitation and partly to abundance of poisonous elements prevailing in such unhealthy waters. The prevalence of fish mortality in jhils, tanks, ponds, etc., in this country causes great economic loss. This phenomenon generally takes place during the hot days before the advent of the monsoon. The cause of such fish mortality may perhaps be partly ascribed to the upsetting of the biological balance by the excess of aquatic vegetation in a jhil, tank or pond.

The great energy of the Micro-phyto-plankton, and the microorganisms at the bottom, absorbing and utilising in various ways the diverse kinds of organic substances resulting in maintaining a biological balance in water, is generally spoken of as the "self-purifying" action of water. For the maintenance of the balance of self-purificatory action of water it is obvious that the lakes, tanks ponds, etc., must be devoid of surface vegetation, Macro-plankton flora and suspended submerged vegetation. The rooted plants utilising the nutrients from the mud should be allowed to grow to a certain limit, as their existence is favourable to the development of Micro-phyto-plankton. From my observation of Indian freshwater vegetation, I am led to support Raymond Haines Pond's modified formula of Kofoid for the development of Micro-phyto-plankton which runs as follows: "The amount of plankton produced by bodies of freshwater is, other things being equal, in some inverse ratio proportional to the amount of its gross non-rooted vegetation and in some direct ratio proportional to the amount of its gross rooted vegetation." The Micro-phyto-plankton is the chief source of food for *Rotifers* and *Crustaceas*, which in their turn serve as food to smaller aquatic animals. These are again devoured by larger fishes which finally form an important diet of human beings.

In these days, when there is a cry everywhere for economic

return of scientific undertakings, and as the value of the results of scientific investigations and discoveries is sometimes estimated in rupees, annas and pies, I may be permitted to emphasise the great commercial importance of pisciculture in this country and particularly in Bengal. In Bengal there is an enormous field for scientific cultivation of fishes which might result in an inestimable money value. As some of the fishes feed on mosquito larvae, fish cultivation is useful for antimalariological work too. Scientific pisciculture leads to biological investigation. In Europe and America it has attained a very high stage of advancement. In our country we are still groping in the dark and speculating about its profit and loss. Proper limnological researches require a team work of biologists, chemists and physicists. The latter to study the plant food in the form of nutrient salts dissolved in the water, physicochemical conditions of varying changes under diverse conditions at different times of the year and so on. Investigations of the relations between plant and animal life, their periodicity and life-history and similar other problems should be tackled by biologists. Our rivers hold potential treasures in sustaining various kinds of edible fauna. Some of the most favourite fishes pass a particularly important period of their life-history in these rivers. The rivers and streams also act as great migratory agents, and the biologists have to reveal the secrets of distribution of the flora and fauna and control their migration in our lakes, jhils, tanks, ponds etc. The salvation of the country, therefore, partly lies in the development of enormous wealth of vegetable and animal resources of the land by modern scientific methods. We should, therefore, spare no pains to gain advancement in the field of biology too. Let us, therefore, proceed *via sacra* in our attempt to peep into the secrets of Nature.

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EXPLANATION OF PLATES III-XI.

PLATE III.

Fig. 1. *Laminaria Cloustoni* (after Drew).

Fig. 2. *Macrocystis pyrifera* (after Skottsberg, Postels and Ruprecht) entire plant attached to the soil of the sea with the apical parts floating on the surface of the water. (W=surface of the water).

Fig. 3. A portion of the frond of *Compsogpogon coeruleus*, x 100.

PLATE IV.

Fig. 1. *Gracilaria confervoides*, natural size.

Fig. 2. *Gracilaria confervoides*, fruiting specimen size.

Fig. 3. *Gracilaria confervoides*, part of the plant with the Cystocarp.

PLATE V.

Fig. 1. (a) A male plant of *Vallisneria spiralis*.
(b-d) Different parts of the male flowers.

Fig. 2. (a) A female plant of *Vallisneria spiralis*.
(b) Female flower. (All much reduced).

PLATE VI.

Fig. 1. Part of the plant showing the leaves and rootstock of *Nymphaea rubra*.

Fig. 2. Two flowers.

Fig. 3. Central part of the flower longitudinally dissected.

Fig. 4. A fruit-transversely cut. (All much reduced).

PLATE VII.

Fig. 1. (a) A young vegetative shoot of *Hydrilla verticillata* with the rootstock.
(b-e) Different parts of the male flower.

Fig. 2. (a) A flowering shoot of the female plant of *Hydrilla verticillata*.
(b) A female flower.
(c) A fruit showing the seeds. (All reduced).

Fig. 3. (a) Part of the shoot of *Utricularia flexuosa*.
(b) An inflorescence.
(c) A bladder at the axil of a leaf.
(d-e) Parts of the flowers showing the stamens, ovary and the fruit, transversely cut showing the seeds. (All reduced).

PLATE VIII.

Fig. 1. Eichhornia speciosa (water hyacinth, a dwarfed form) with a young plant developing from the offset. (Reduced).

Fig. 2. Salvinia cuculata. (Reduced).

Fig. 3. Pistia Stratiotes. (Reduced).

Fig. 4. (a) Part of the shoot of Trapa bispinosa.
(b) part of the green filiform adventitious and normal roots.
(c) A small portion of the stem with part of the petiole, leaf and chlorophyl bearing filiform adventitious roots, (the so-called stipules of Roxburgh and others).
(d) a flower opened out.
(e-f) Fruits (All reduced).

Fig. 5. Azolla pinnata (Reduced).

Fig. 6. *Lemna paucicostata*. Slightly reduced.

Fig. 7. *Lemna polyrrhiza*. Slightly reduced.

Fig. 8. Part of the frond of *Nitella mirabilis*, natural size.

PLATE IX.

Fig. 1. Part of the thallus of *Enteromorpha prolifera*, x 10.

Fig. 2. Part of the thallus of *Enteromorpha intestinalis*, (after Kützing).

Fig. 3. Part of the filament of *Lyngbya aestuarii*, x 1000.

Fig. 4. (a) Filaments of *Lyngbya ochracea* encrusted with iron hydroxide, x 650.
(b) Part of the filament with the sheath, x 650.
(c) Part of the filament treated with hydrochloric acid showing the cells, x 650.

Fig. 5. Colonies of *Clathrocystis aeruginosa*, x 500.

Fig. 6. Part of the filament of *Anabaena flosaquae*, x 500.

Fig. 7. A single filament of *Spirulina major*, x 1000.

Fig. 8. *Syndra affinis*, var *fasciculata*, x 1000.

Fig. 9. (a) *Gonium pectorale*, a 16 celled colony, x 200;
(b) a four celled colony, x 500.

Fig. 10. *Scendesmus quadricauda*, a four celled colony, x 1000.

Fig. 11. *Ankistrodesmus falcatus*, x 850.

Fig. 12. *Cosmarium granatum*, x 500.

Fig. 13. *Penium Libellula*, x 200.

Fig. 14. *Staurastrum manipurense*, front view, x 950.

PLATE X.

Fig. 1. (a-b),Part of the frond of *Grateloupia filicina* natural size.
Fig. 2. *Podostemon Wallichii* x 5.
Fig. 3. Part of the thallus of *Enteromorpha compressa* natural size.
Fig. 4. Part of the filament of *Tribonema bombycinum*, x 650.
Fig. 5. Part of the thallus of *Cladophora crispata*, var. *genuina*, x 100.
Fig. 6. Part of the thallus of *Hydrodictyon reticulatum* x 300.
Fig. 7. Part of the filament of *Oscillatoria tenuis*, x 1000.
Fig. 8. Part of the filament of *Gloetrichia natans*, x 500.
Fig. 9. *Syndra ulna*, x 400.
Fig. 10. *Euglena viridis*, (a-b) normal forms, (c) encysted stage, x 500.
Fig. 11. *Pediastrum duplex*, var. *clathratum*, x 450.
Fig. 12. *Chlorella vulgaris* x 700.

PLATE XI.

Succession of aquatic vegetation in different zones of an Indian pond.

A. 1. *Colocasia antiqurum*.
2. *Marsilea quadrifoliata*.
3. *Eleocharis plantaginea*.
4. *Nitella and Chara*.
5. *Limnanthemum indicum*.
6. *Nelumbium speciosum*.
7. *Nymphaea rubra*.
9. *Vallisneria spiralis*.

} Lemnaea formation of Benthos of loose soil.

Hydrocharid Formation.

10. *Eichhornia speciosa*.
11. *Pistia Stratiotes*.
12. *Salvinia cuculata*.
13. *Lemna polyrrhiza and Lemna paucicostata*
14. *Azolla pinnata*.
15. *Utricularia flexuosa*.
16. *Tricho-plankton of filamentious algae*.

} Macro-phyto-plankton.

17. *Ceratophyllum demersum*.
18. *Hydrilla verticillata*.

} Pleuston.

B. 19. *Vallisneria spiralis*.
20. *Chara*, *Nitella* and *Tolypella*.
21. *Potamogeton crispus*.

} Limneae formation of Benthos of loose soil.

22. *Clathrocystis aeruginosa*, *Micro-phyto-plankton*.
W=surface of water.
V=vital layer.
A. showing water plants nearly in all the strata.
B. showing sparse bottom vegetation and Micro-phyto-plankton.
Scale 1/4 in=1 foot.

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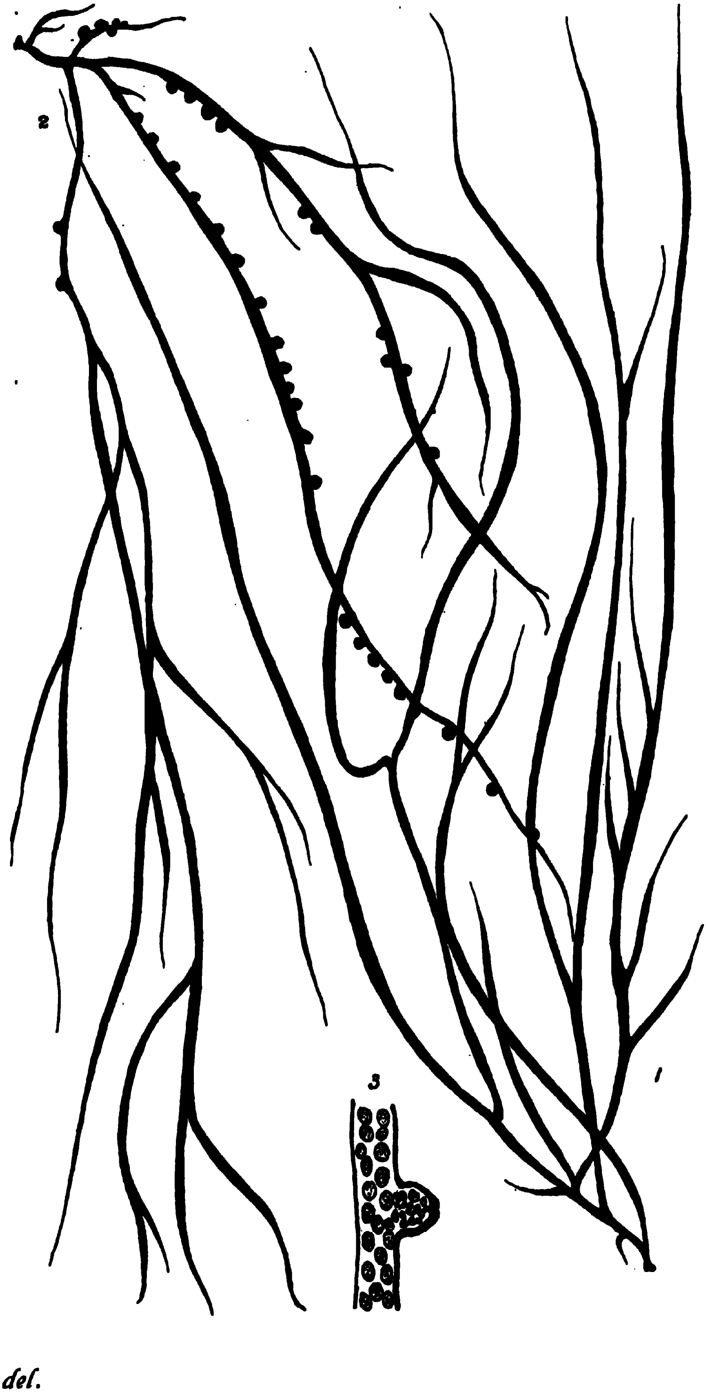

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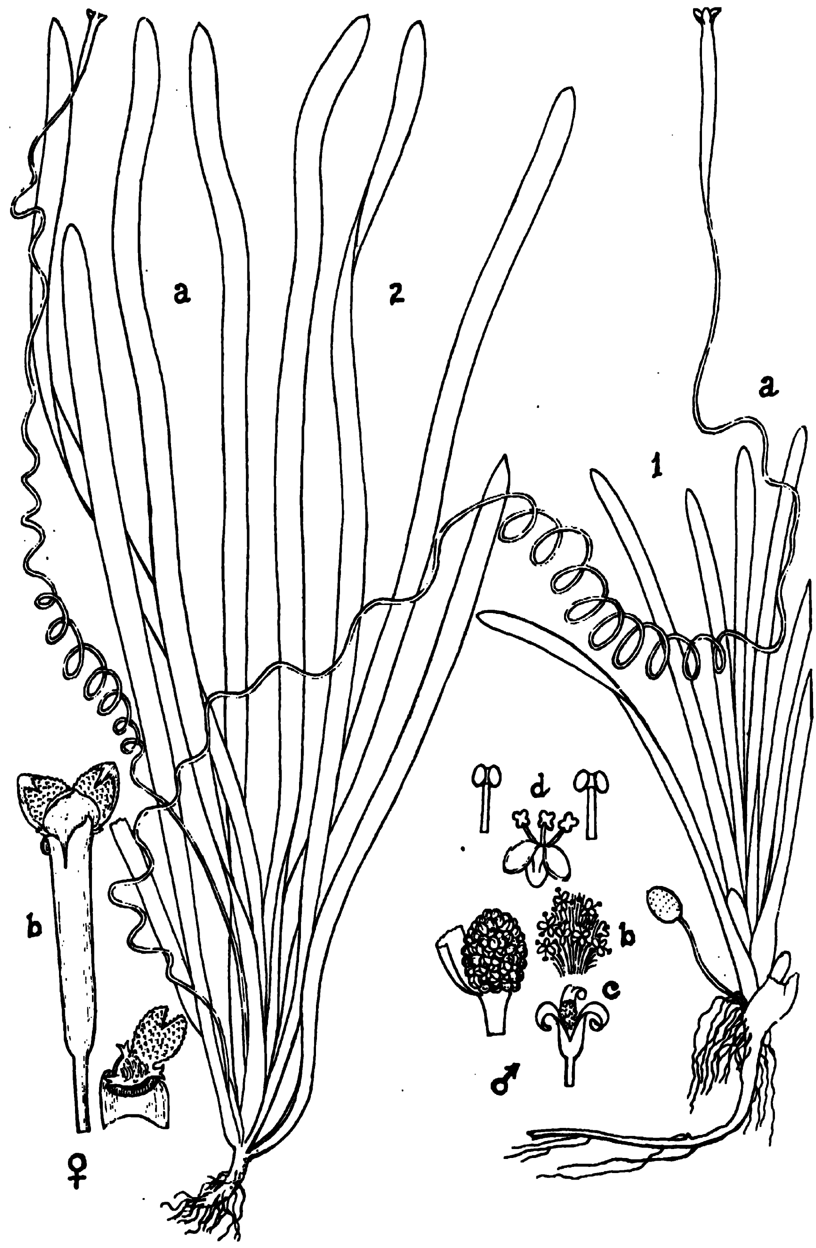

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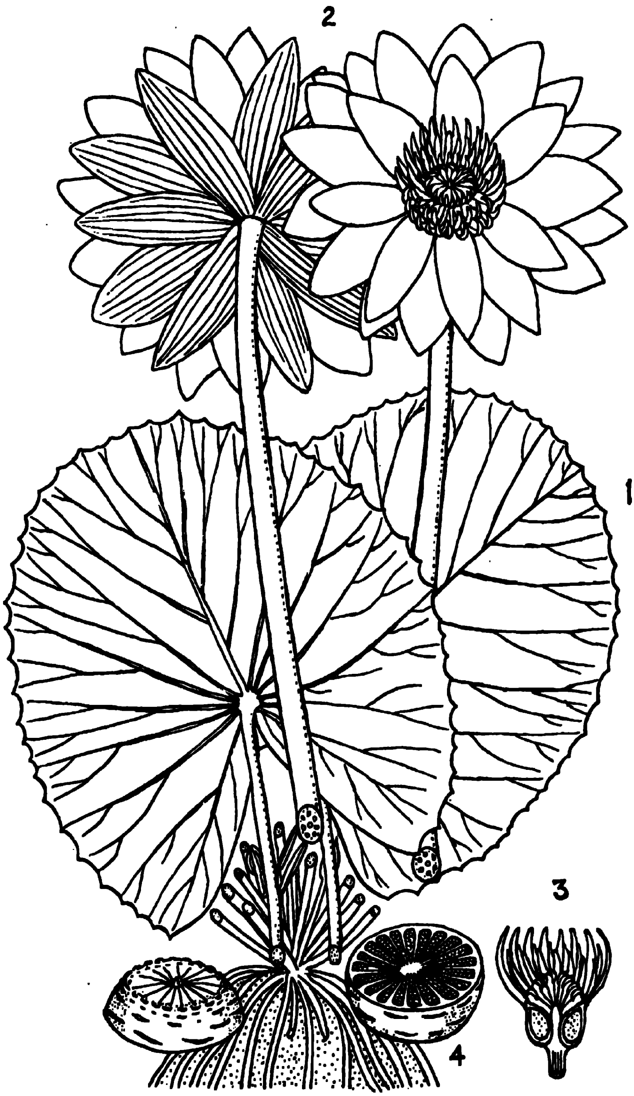

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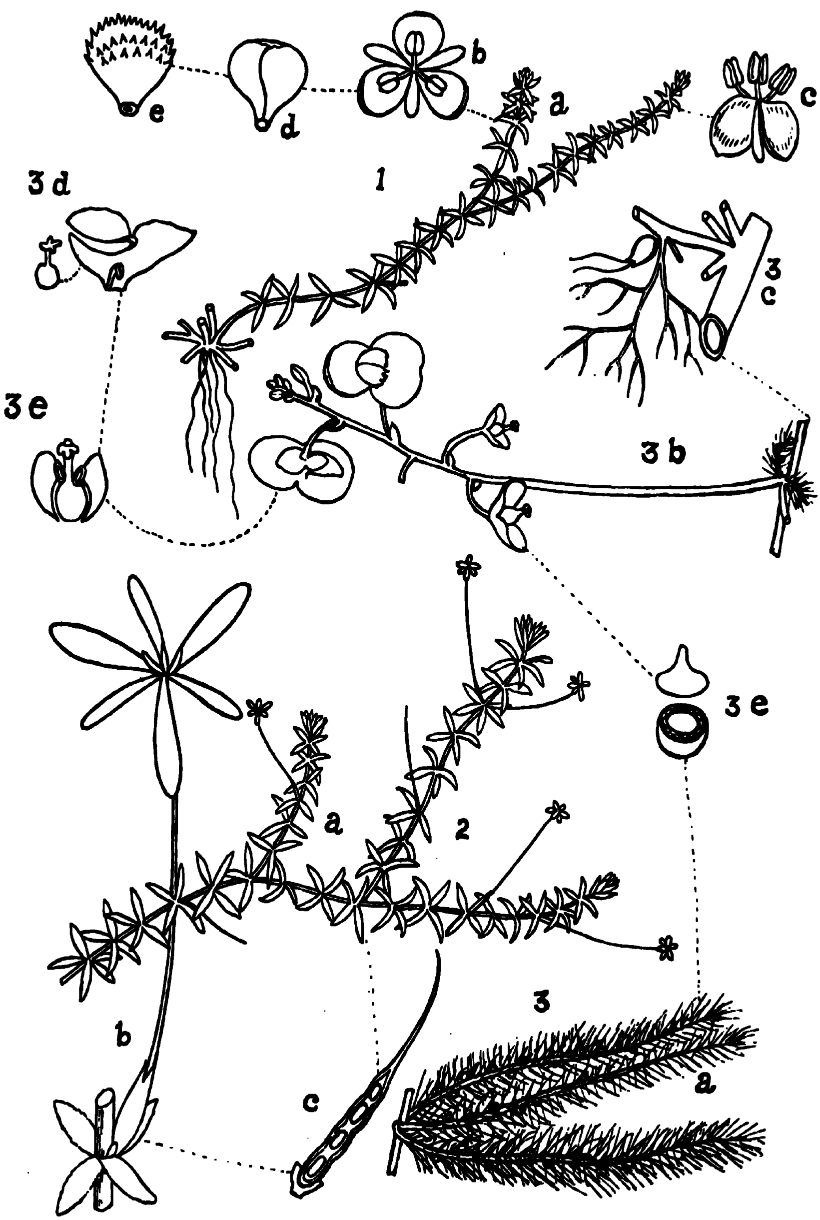

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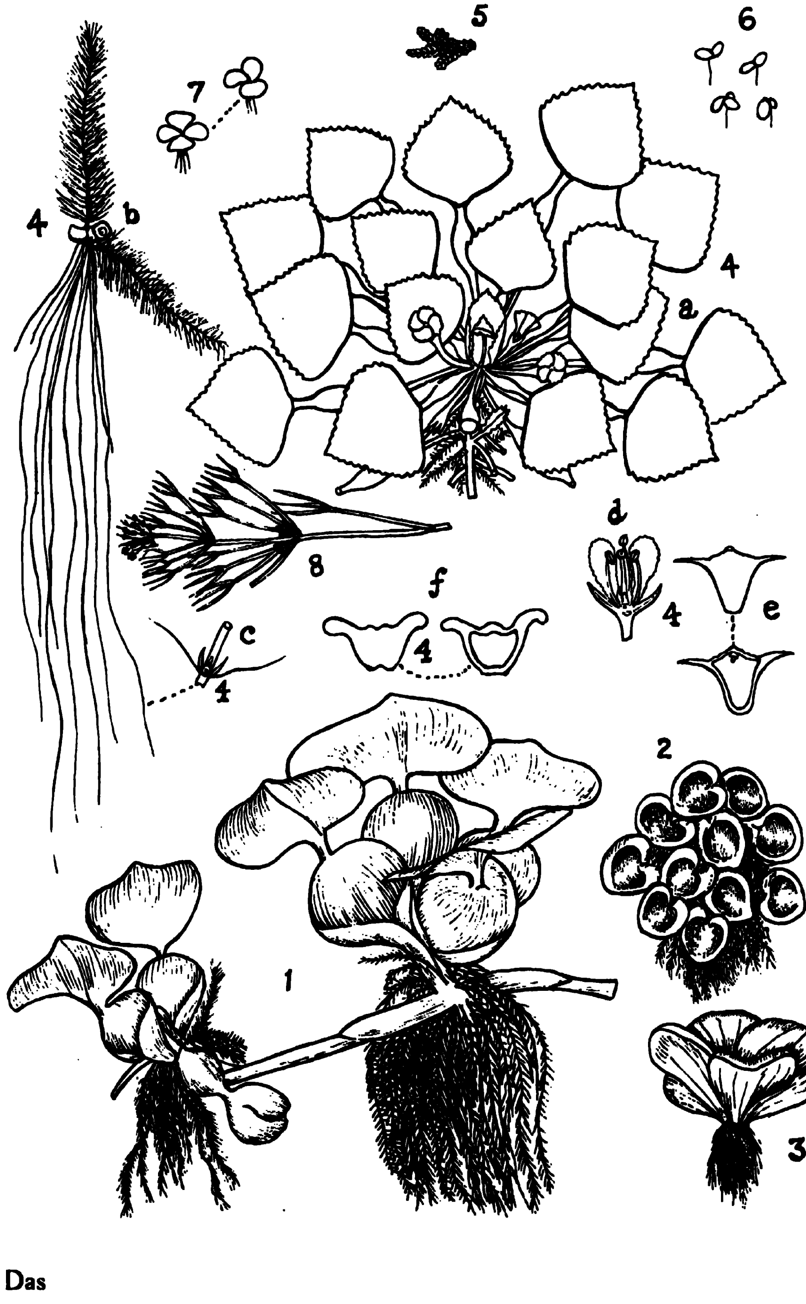

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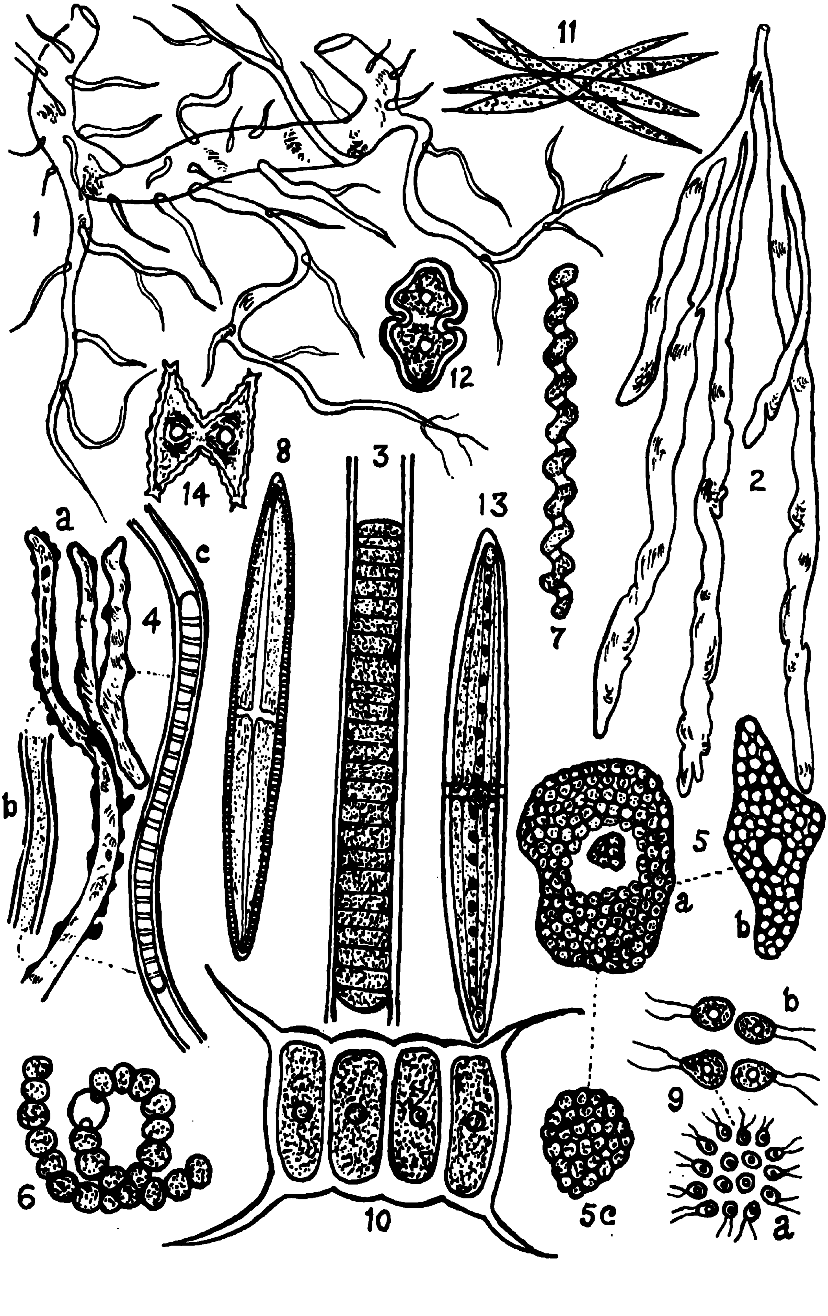

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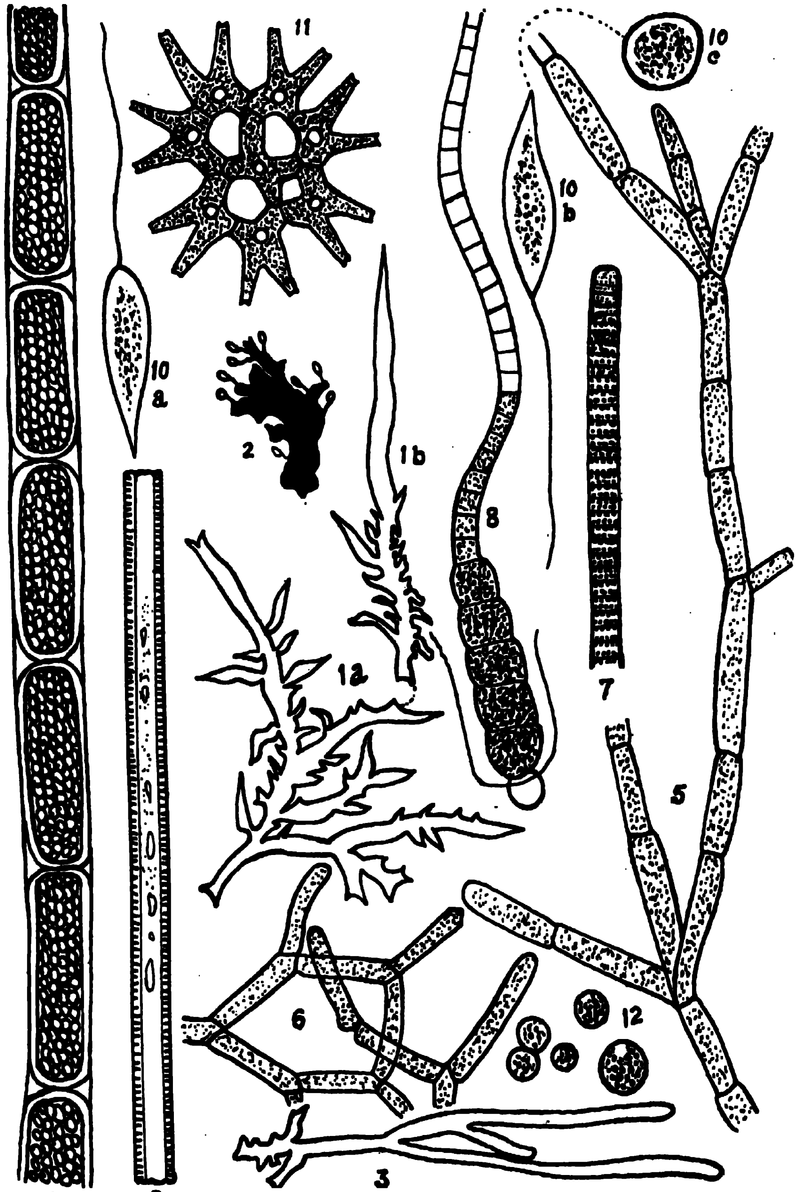

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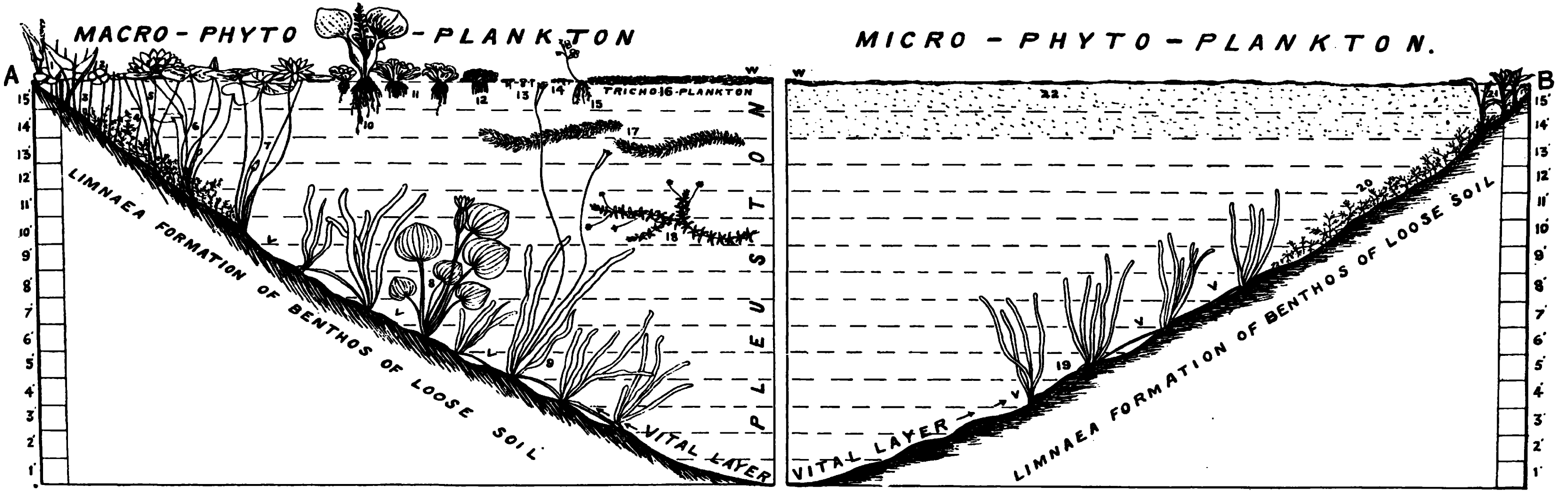

SUCCESSION OF AQATIC VEGETATION IN DIFFERENT ZONES OF AN INDIAN POND.

A – SHOWING WATER PLANTS NEARLY IN ALL THE STRATA.

B – SHOWING SPARSE BOTTOM VEGETATION AND MICRO-PHYTO-PLANKTON.

W = SURFACE OF WATER.

K. Biswas *del.*

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The Doctrine of Symmetry in Chemistry and its Significance to Molecular Configuration

By Bawa Kartar Singh (Cuttack).

Among the ideas which have played an important rôle in science, the doctrine of symmetry may certainly be considered as one of the most remarkable and fruitful. Its significance and value for the scientific description of the living and inanimate matter has been recognised from early times.

The idea of symmetry resulted originally from a study of the geometrical forms of natural objects (1). In Biology, Haeckel was one of the first to understand the great value of the principle of symmetry for the description of plants and animals. He drew attention to the symmetrical and highly aesthetic forms of lower being in his works on the "*Radiolaries*" and "*Kuntsformen der Natur.*" In these studies the word "*symmetry*" was used to convey the idea of some kind of geometrical regularity, and of certain processes of repetition manifested in the external habits of natural objects. The aesthetic factor implied in the mere repetition of a visual impression also led to the introduction of the principle of symmetry in decorative art and architecture.

The doctrine of symmetry also played an important part in the development of chemical science. The principles and ideas which were gathered together under this doctrine found application in the elucidation of molecular configuration of chemical compounds. Thus the laws which were found to hold good in the case of objects, which can be measured by our visual apparatus, were also found applicable in the case of objects, the dimensions of which will most probably for ever remain beyond the scope of our direct observations.

Symmetrical objects may be defined as those which are similar

to themselves, or to their mirror-images in *more than one way*, because every object is equal to itself by mere identity. They are superposable with their mirror-images. A sphere is a good example of this class of objects. There are other objects, like right and left hand, which do not fulfil these conditions. They differ from their mirror-images in being non-superposable. Such objects are called *enantiomorphous*, and do not possess a centre of symmetry, an axis of symmetry, or a plane of symmetry.*

The phenomenon of enantiomorphism and of enantiomorphous arrangement in space has played a great part in the development of our chemical ideas, and has enabled us to understand the configuration of chemical compounds. It is proposed to treat this subject from a historical standpoint, and to indicate its significance to chemistry.

Our present conceptions of the structure and configuration of molecules are the result of much speculation and experimental investigation during the last one hundred and twentyfive years. The atomic theory of Dalton, enunciated in 1803, and the hypothesis of Avogadro formulated in 1813 were two great theoretical concepts which gave powerful stimulus to chemical research and led to the association of a definite physical meaning with the idea of molecular composition. The discovery of the Law of Isomorphism by E. Mitscherlich in 1819 was of very great assistance in fixing the relative atomic weights of elements, and thus gave great stimulus to the development of atomic theory. The discovery of the phenomenon of isomerism by Gay-Lussac in 1824 proved to be of immense value in the evolution of the theory of molecular structure of organic compounds. The synthesis of urea by Wohler in 1828—one of the first classical examples of organic products built up in the laboratory—broke down the distinction of a '*vital force*' in the chemistry of living and non-living matter. The Theory of Radicals (1832) propound-

*The reverse of this proposition is, however, not true. The absence of a centre of symmetry, an axis of symmetry, or a plane of symmetry does not *necessarily* make an object differ from its mirror-image, or give rise to enantiomorphism.

ed by Liebig and Wohler was the first attempt in gaining an insight into the structure of compounds. This was followed by Dumas' Theory of Types (1839). The theories of Radicals and Types were combined by Gerhardt and for ten years (1848-58) were the basis of all investigations in organic chemistry. These theories, however, proved insufficient for the interpretation of a large number of facts relating to isomeric phenomenon collected under their impetus. A further great advance was only made possible when Kekulé in 1858 introduced into chemistry his doctrine of valency, and the law of the linking of atoms. The conception of molecular constitution followed as a necessary corollary of this new doctrine, and led to clearer ideas about the constitution of chemical compounds by means of their graphic formulae.

Atomic Dissymmetry

Once more the theoretical scheme proved insufficient to embrace all the known facts, until in 1874, Van't Hoff (2) and Le Bel (3) independently demonstrated the all important part which molecular configuration plays in the interpretation of certain cases of isomerism in organic chemistry. They ascribed the optical activity of organic compounds to the presence of one or more asymmetric carbon atoms.

Molecular Dissymmetry

The introduction of the novel idea of molecular dissymmetry into chemistry was due to the discovery of two pairs of acids, which were destined to play an important part in the creation of the new science of stereochemistry, namely, racemic acid (Gay-Lussac, 1826) isomeric with tartaric acid, and lactic acid (Scheele, 1780), isomeric with paralactic or sarcolactic acid. This advance resulted from the crystallographic investigations of Pasteur (4) on the first pair of acids and their salts. It was in 1848 that this brilliant young chemist, at the very beginning of his scientific career, made the epoch-making discovery that when sodium-ammonium racemate was crystallised from an aqueous solution at low temperature, it deposited two kinds of crystals, which were related to one another as an object is to its non-superposable mirror-

image. Both kinds showed similar hemihedral facets, but these were arranged in exactly opposite manner. The solution of the salt with right hemihedral facets was dextro-rotatory, and that of the salt with left hemihedral character was laevo-rotatory to an equal extent. Further on mixing these two solutions optical activity disappeared. The free acids liberated from both kinds of crystals, after careful selection, had the same composition as the racemic acid itself. They also possessed equal and opposite rotation. When a mixture of equal weights of the two acids was crystallised, the product was identical with racemic acid. Pasteur's acute judgment at once led him to conclude that the molecules of two tartaric acids were the same in composition and structure, differing in spatial arrangement such that one was the enantiomorph of the other. This could be the case only if their configurations were tri-dimensional and were related to one another as an object is to its non-superposable mirror-image, owing to the existence of molecular dissymmetry. The history of science has rarely witnessed a discovery that has had such far reaching consequences in Physics and Chemistry as this one by Pasteur.

At the time of this discovery (1849) the theory of Kekulé had not been advanced, and, therefore, it was not possible for Pasteur to point out more precisely the spatial arrangement of the atoms in the molecules. The insufficiency of two-dimensional formula of Kekulé was gradually being recognised, and other suggestions of three-dimensional models were now forthcoming. In 1869 several chemists put forward spatial ideas. Ladenberg's prism formula for benzene (5) and its representation by six tetrahedrons by Rosentiehl clearly involved spatial considerations. Wislicenus' work (6) on the different modifications of lactic acid led him to explain their differenec on spatial grounds. By the year 1874 sufficient material was ready to develop the broad outlines of chemistry in space. It was, therefore, no mere coincidence that the conception of the asymmetric carbon atom was put forward independently by Le Bel and Van't Hoff. The time for this discovery was indeed so ripe that both of these discoverers would have had to yield priority to an Italian chemist, if it had not been that

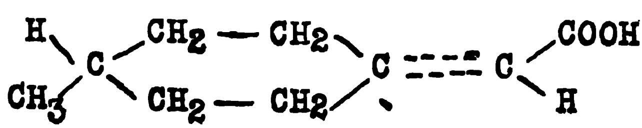
one of the three dibromo-ethanes which Paterno (7) in 1869 sought to explain by means of a three-dimensional carbon atom turned out to be non-existent. The conception of atomic asymmetry has done great service in the development of stereochemistry, and optically active derivatives of not less than 18 elements other than carbon may be recorded as follows: nitrogen (8 and 9), sulphur (10), selenium (11), tin (12), phosphorous (13), silicon (14), boron (15), arsenic (16), beryllium (17), zinc (17), copper (17), chromium, cobalt, ruthenium, rhodium, iridium, iron and platinum.

The doctrine of the asymmetric atom, as formulated by Van't Hoff, involves two factors: (i) the dissymmetric arrangement of the atoms or groups in the molecule, and (ii) chemical differences in these atoms or groups. Later research has shown that the view that both these factors should be present *together* to give rise to enantiomorphism is untenable. It is possible to conceive of geometrical complexes and arrangements in space built up of identical parts or units, giving rise to configurations differing from their mirror-images. In this case the "chemical contrast" between the substituents will be lacking. Several instances of chemical molecules of this type are now known in which the optical activity must be ascribed to the dissymmetric arrangement in space of identical parts. Werner (18) in his brilliant researches on the co-ordination compounds of the trivalent metals, Co, Cr, Pb, Fe, etc., having the co-ordination number *six*, and represented by the general formula Me $[X''_3]$ R_3 in which X'' is a bivalent radical or group, has shown that these compounds can be resolved into two enantiomorphous isomers. Notwithstanding the fact that the substituents which they contain are all identical, they possess enormous rotatory power, surpassing anything met with in carbon compounds [Singh (19)]. The rotatory power of tri-d-hydroxy methylene camphor complex salt of trivalent cobalt (20) measured in methyl alcohol is enormous and is not less than $-240{,}000^\circ$. Another remarkable compound, prepared by Jorgenson (21) and resolved by Werner (22) is the tri- (tetrammino-diol-cobaltic) cobaltic hexachloride,

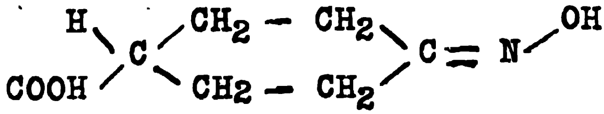
$$\overset{\cdots}{Co}\left[\begin{matrix}(OH)\\(OH)\end{matrix}\cdot Co(NH_3)_4\right]_3 Cl_6$$

in which the complex, $\left[\begin{matrix}(OH)\\(OH)\end{matrix}\ Co(NH_3)_4\right]$

evidently plays the same part as does the tri-hydroxy methylene camphor molecule in the foregoing compound, or the tri-ethylene-diamine molecule in the luteo salts. The molecular rotatory power of the optically active form is not less than 47,600° for $\lambda = 5600$ A. This compound is also of special theoretical interest, as it does not contain even a single carbon atom, and thus establishes the fact that the presence of carbon derivatives in such complexes is not at all a necessary condition for the manifestation of high rotatory power. If we examine the atomic arrangement of these molecules on Werner's co-ordination theory it will be found that although they are composed of even *identical* units, and possess a rather *highly symmetrical configuration*, they are different from their mirror-images. They can, therefore, exist in two enantiomorphously related isomers. The enormous rotatory power, which they possess, must be attributed to the non-superposable arrangement of the molecule as well as to the central metallic atom, and not to any *chemical contrast* between the groups round the plurivalent atom. These complex compounds of Werner vividly illustrate the inadequacy of the Van't Hoff Theory of the asymmetric atom. Their optical activity cannot be assigned specifically to any one asymmetric or dissymmetric atom in the molecule, but must be attributed to molecular dissymmetry. Other examples of molecular dissymmetry which may be cited include the centro-asymmetric compound prepared by Perkin, Pope and Wallach (23) in 1909, namely, methyl-cyclo-hexylidene acetic acid:

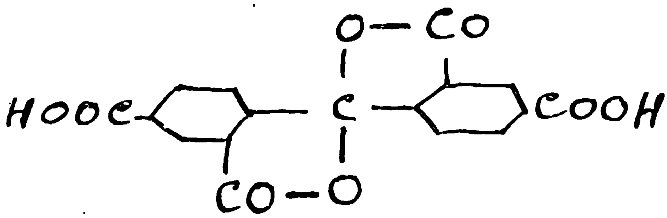


A similar compound prepared by Mills and Bain (24) in the following year, is the oxime of cyclo-hexanone-carboxylic acid,



which owes its dissymmetry to the fact that the three bonds of the doubly linked nitrogen atom are not coplanar.

Another compound prepared by Mills and Nodder (25) in 1921 is the keto-dilactone of benzophenone-tetracarboxylic acid,



in which the central atom of carbon is dissymmetric and not asymmetric. All these compounds have been shown to exist in enantiomorphously related optically active forms.

The correlation of the property of optical activity with molecular dissymmetry by Pasteur has enabled the chemist to understand the properties of chemical molecules and to depict their molecular structure in space. It has brought out very realistically that the molecules, like other natural objects, have tri-dimensional configuration. The idea is barely ninety years old, when Pasteur at the commencement of his brilliant scientific career, discovered those fundamental facts, which constitute the very foundation of modern stereochemistry.

The recognition of the phenomenon of enantiomorphism in natural objects, which can be brought under our direct measurement on account of their convenient size, resulted in their division into two groups—symmetric and dissymmetric. The chemical molecules, being of infinitesimally small size, could not be observed by these direct measurements. The discovery of Biot (1815) that certain liquid organic substances deflect the plane of polarised light, either to the right or to the left, was of far-reaching consequence. The

conception of molecular dissymmetry, introduced by Pasteur 30 years later, was the direct outcome of the capital discovery of the French physicist. It led him to conclude that the molecules of optically active substances, like the two optically active and opposite tartaric acids, exhibit enantiomorphism. It, therefore, followed that their configurations were tri-dimensional, and were related to one another as an object is to its non-superposable mirror-image, owing to the existence of molecular dissymmetry. Chemical molecules, like natural objects, could also be divided into two groups—symmetric and dissymmetric. As dissymmetric molecules were shown to be tri-dimensional, it was natural to conclude that symmetric organic molecules, which do not show optical activity and enantiomorphism, also possess a tri-dimensional configuration. In this way the idea of a tri-dimensional configuration came to be associated with the organic chemical molecule.

The great significance of the doctrine of symmetry in chemistry is thus brought out when it is realised that by the application of the laws of symmetry it has been definitely established that the architecture of the chemical molecule is not planar, but tri-dimensional.

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ব্রহ্মাণ্ডের আকার

ব্রহ্মাণ্ডের আকার এবং বিস্তৃতি সম্বন্ধে আলোচনা করিতে হইলে প্রথমতঃ যাবতীয় সৃষ্ট পদার্থ এবং তাহাদের পরস্পরের ব্যবধান সম্বন্ধে একটা মোটামুটি ধারণা করা চাই। জিওগ্রাফি পড়িতে প্রথমতঃ নিজের বাড়ীর পরিচয় লইয়াই আরম্ভ করিতে হয়; সুতরাং ব্রহ্মাণ্ডের জিওগ্রাফির বেলায়ও আমরা ঘরের কথাই প্রথম বলিব। এখানে সৌরজগৎ আমাদের গৃহ। ইহার কেন্দ্রে সূর্য্য বুধ, শুক্র, পৃথিবী, মঙ্গল ইত্যাদি নব-আবিষ্কৃত প্লুটু পর্য্যন্ত ৯টী গ্রহ ও বহু উপগ্রহ বেষ্টিত এবং ইহারা সকলেই জড়-আকর্ষণের ফলে সূর্য্যের চারিদিকে ঘুরিতেছে। যে বৃত্তপথে পৃথিবী ঘুরিতেছে তাহার ব্যাসার্দ্ধ ৯ কোটি ২০ লক্ষ মাইল। আমাদের দৈনিক জীবনের মাপকাঠিতে এই দূরত্ব অত্যন্ত বেশী মনে হইলেও জ্যোতিষশাস্ত্রের মাপকাঠিতে ইহা একেবারে নগণ্য। কিন্তু নগণ্য হইলেও অন্যান্য জ্যোতিষ্কের দূরত্বনির্ণয়ে ইহার সহিত তুলনার সাহায্য বরাবর লওয়া হইয়া থাকে। নেপচুন গ্রহ সূর্য্য হইতে প্রায় ২৮০ কোটি মাইল দূরে এবং তাহার পর প্লুটু। সুতরাং সৌরজগতের বিস্তৃতি আমরা মোটামুটি ৩৫০ কোটি মাইল ধরিতে পারি। প্লুটুর পর আরও অন্য গ্রহ থাকা অসম্ভব মনে হয় না; কিন্তু তাই বলিয়া সৌরজগতের অসীম বিস্তৃতি অসম্ভব। প্রত্যেক গ্রহই কেন্দ্রীয় সূর্য্যের জড় আকর্ষণের ফলে স্বীয় কক্ষায় ঘুরিতেছে। এই বৃত্তাকারে গতির জন্য প্রত্যেকেরই কেন্দ্র হইতে বিপরীত দিকে চলিবার একটি চেষ্টা হয়। সূর্য্যের জড়-আকর্ষণ এই চেষ্টাকে বিফল করিয়া গ্রহটিকে আপন কক্ষায় ধরিয়া রাখে। সূর্য্য হইতে দূর অত্যধিক হইলেই গ্রহের কেন্দ্র হইতে বহির্মুখী গতি রোধ করিতে সূর্য্যের জড়-আকর্ষণ অসমর্থ হইবে কাজেই স্বীকার করিতে হইবে আমাদের সৌরজগৎরূপ সৃষ্টির একটা শেষ আছেই। মোটামুটি ইহার ক্ষেত্র ৩৫০ কোটি মাইল ধরিলাম।

সৌরজগৎ ছাড়িয়া আমাদের নিকটতম প্রতিবেশীর নিকট পৌঁছিতে প্রকাণ্ড একটা শূন্য পার হইতে হয়। এই প্রতিবেশী একটি তারা,—নাম প্রক্সিমা সেণ্টরি। মাঝামাঝি ফাঁকটা এত বড় যে সাধারণভাবে তাহার ধারণা করা অসম্ভব। ১০০ মাইল ঘণ্টায় বেগ এমন একস্প্রেসে চড়িয়া অনবরত চলিয়াও হাজার হাজার বৎসরে প্রতিবেশীর নিকট পৌঁছান অসম্ভব। কিন্তু তাহার দূরত্ব প্রকাশ করার একটা পন্থা জ্যোতিষিদের বিদিত আছে। অনেক পরীক্ষা দ্বারা স্থির হইয়াছে যে আলো প্রতি সেকেণ্ডে ১৮৬ হাজার মাইল চলে। ইহা অপেক্ষা দ্রুততর গতি আমাদের পক্ষে অসম্ভব। এই আলো সেকেণ্ডে ১৮৬ হাজার মাইল চলিয়া এক বৎসরে যতদূর যায় তাহাকে আলোকবর্ষ বলা যাইতে পারে। আলোকবর্ষ একটি দূরত্বের পরিমাণ। প্রক্সিমা সেণ্টরি হইতে আলোক আমাদের নিকট পেঁাছিতে প্রায় ৪৷৷০ বৎসর লাগে। সুতরাং বলা যাইতে পারে আমাদের নিকটতম প্রতিবেশী ৪৷৷০ আলোকবর্ষ দূরে বাস করেন। তুলনার জন্য স্মরণ করা আবশ্যক যে সূর্য্যের আলোক মাত্র ৮ মিনিটে পৃথিবীতে পৌঁছায়। এই দূরত্বের কল্পনা অন্য এক প্রকারেও করিতে পারি। পূর্ব্বেই বলা হইয়াছে যে পৃথিবীর কক্ষার ব্যাসার্দ্ধ ৯ কোটি ২০ লক্ষ মাইল। এই বৃহৎ বৃত্তকে যদি এক ইঞ্চি পরিমাণ একটি পয়সার মত কল্পনা করি তবে দেখা যায় সেই অনুপাতে আমাদের নিকটতম প্রতিবেশীর দূরত্ব প্রায় ৭৫ মাইল। সৌর-জগতের খুব নিকটে ছোট বড় যে সকল তারা আছে, তাহাদের কতকগুলির দূরত্ব মাপা হইয়াছে। দেখা যায় প্রায় ১৫।১৬ আলোকবর্ষের মধ্যে ২৪।২৫টি তারা আছে। আকাশের সর্ব্বাপেক্ষা উজ্জ্বল তারা লুব্ধকের দূরত্ব ৮৷৷০ আলোক-বর্ষ। সাধারণতঃ চোখে ৫।৬ হাজার তারার বেশী দেখা যায় না। ১ ইঞ্চি টেলিস্কোপের সাহায্যে এই সংখ্যার আরও ১২৫ গুণ বেশী তারা দেখার কথা; কিন্তু প্রকৃত পক্ষে তাহার কম দেখা যায়। ইহার কারণ এই যে অনেক তারার আলো এত ক্ষীণ যে টেলিস্কোপের কাচের ভিতরই তাহা লয় পায়। ১ ইঞ্চি টেলিস্কোপে আমরা শুধুচোখের পাঁচ গুণ দূর পর্য্যন্ত দেখিতে পাই। কাজেই এই দূরত্বের মধ্যে যদি তারার সংখ্যা না কমিয়া যায় তবেই ১২৫ গুণ তারা দেখিতে পারা যাইবে। মোটে যদিও ১২৫ গুণ দেখা না যায় তবু মনে করিবার যথেষ্ট কারণ আছে যে ইতিমধ্যে তারার সংখ্যা কমে নাই। তারার হ্রাসবৃদ্ধির পরিমাপস্বরূপ মহাকাশে তারার ঘনতা কি

তাহা নির্ণয় করা হয়। সূর্য্যের নিকটবর্ত্তী যে সব তারা আছে, তাহাদের ঘনতা এই প্রকারে কল্পনা করা যাইতে পারে। মহাকাশকে যদি সমানভাবে কতকগুলি প্রকোষ্ঠে বিভক্ত মনে করা যায় যাহাদের প্রত্যেকের দৈর্ঘ্য, প্রস্থ, উচ্চতা ৬॥০ আলোকবর্ষ, তবে তাহাদের প্রত্যেকের মধ্যস্থলে একটি তারা রাখিলে সৌরজগতের নিকটবর্ত্তী তারার ঘনতার ঠিক পরিচয় দেওয়া হয়। প্রায় দশ বৎসর পূর্ব্বে জ্যোতিষী ক্যাপ্টেন তাহার বহুকালব্যাপী পরীক্ষা ও গণনার ফলস্বরূপ সৌরজগতের নিকটবর্ত্তী তারাজগতের একটি মানচিত্র প্রকাশ করেন। তিনি প্রথমতঃ ইহাই পরীক্ষা করেন যে আকাশের কোনও নির্দ্দিষ্ট দিকে টেলিস্কোপের সাহায্যে যদি তারা গণনা করা যায়, তবে দূরত্বের সহিত তারার ঘনতার পরিবর্ত্তন হয় কিনা ? মোটামুটি দেখা যায় যে তারার ঘনতা দূরত্বের সহিত হ্রাস হয় ; কিন্তু এই হ্রাসের হার বিভিন্ন দিকে বিভিন্ন। আকাশে যে ছায়াপথ দেখা যায় তাহার দিকে তারা খুব ঘন-সন্নিবিষ্ট এবং তারার ঘনতার হ্রাসের হার কম। ছায়াপথটি আকাশে প্রায় বৃত্তাকারে অবস্থিত ; এই বৃত্তের উত্তর এবং দক্ষিণে তারার সংখ্যা অনেক কম এবং ঘনতার শীঘ্রই হ্রাস হয়। মোটামুটি বলা যাইতে পারে যে ছায়াপথের সমতলে কোন নির্দ্দিষ্ট ব্যবধানে তারার যে ঘনতা, ছায়াপথের উত্তর এবং দক্ষিণে ঐ দূরত্বের এক পঞ্চমাংশের মধ্যেই সেই ঘনতা দৃষ্ট হয়। এই শেষোক্ত দিকে তারার সংখ্যা পূর্ব্বোক্ত দিক অপেক্ষা পাঁচ গুণ বেগে হ্রাস পায়। ক্যাপ্টেনের এই আবিষ্কার বহুমূল্য হইলেও তাঁহার পরীক্ষা হইতে এই সিদ্ধান্ত করা যায় না যে তারাজগৎ দূরত্বের সহিত ক্রমেই সমাপ্ত হইয়া আসিতেছে। বস্তুতঃ বড় টেলিস্কোপের সাহায্যে জানিতে পারা যায় যে ক্যাপ্টেনের মানচিত্র সমস্ত তারাজগতের এক ক্ষুদ্রাংশের ছবি মাত্র। কিন্তু তারাজগতের সঙ্গে ছায়াপথের যে খুব ঘনিষ্ঠ সম্বন্ধ আছে তাহা এই অসম্পূর্ণ চিত্র হইতেই স্পষ্ট বোঝা যায়। ছায়াপথটি শুধু চোখে দেখিতে একটি অস্পষ্ট আলোকরেখার মত। বড় টেলিস্কোপের সাহায্যে দেখা যায় উহা অতি ঘনসন্নিবিষ্ট তারার সমষ্টি মাত্র। হংসসমষ্টির (সিগ্‌নাস্) নিকট এই রেখা দ্বিধা বিভক্ত হইয়া দুইটি সমান্তরাল আলোক-রেখারূপে ধনুরাশি (সেগিটারিয়াস্) পর্য্যন্ত বিস্তৃত। তাহার পর এই দুই রেখা আবার মিলিত হইয়াছে। বিভক্ত সমান্তরাল রেখা দুইটি খুব উজ্জ্বল, কিন্তু তাহার মধ্যস্থল কালো,—মনে হয় ঐস্থান নক্ষত্রবিরল। বহুকাল পর্য্যন্ত

জ্যোতির্বিদেরও এই বিশ্বাস ছিল; কিন্তু সম্প্রতি নূতন আবিষ্কারের সঙ্গে সঙ্গে এই ধারণা সুস্পষ্ট হইয়াছে যে স্থানটি নক্ষত্রশূন্য বলিয়া কালো নয়; পরন্তু পশ্চাদ্‌বর্ত্তী ছায়াপথের নক্ষত্রজগৎ এবং সৌরজগতের মধ্যস্থলে এক প্রকাণ্ড আলোকহীন কালো নীহারিকাপুঞ্জ বিদ্যমান। নীহারিকাপুঞ্জই ছায়াপথকে দ্বিধা বিভক্ত করিয়াছে। এইরূপ নীহারিকাপুঞ্জের অনেক আলোকচিত্র বর্ত্তমানে বৃহৎ টেলিস্কোপের সাহায্যে লওয়া হইয়াছে। আলোকবিশ্লেষণ দ্বারা ছায়াপথের নক্ষত্রজগতে আরও দুই প্রকার নীহারিকাপুঞ্জ আবিষ্কার করা হইয়াছে। তাহাদের কতকগুলি সবুজ কতকগুলি শাদা। সবুজগুলিতে সবুজ আলো ছাড়া মোটামুটি আর কিছু পাওয়া যায় না। শাদাগুলিতে সূর্য্যালোকের মত সকল আলোই দৃষ্ট হয়। সবুজগুলি ছায়াপথজগতের অংশ, শাদাগুলি তারার সমষ্টি এবং তাহাদের দূরত্বের পরিমাণ দ্বারা বোঝা যায় যে তাহারা ছায়াপথের নক্ষত্রজগৎ হইতে বহুদূরে। ছায়াপথের নক্ষত্রজগতের এক প্রান্ত হইতে অপর প্রান্ত যদি প্রায় ৫০ সহস্র আলোক-বর্ষ হয়, তবে শাদা নীহারিকাপুঞ্জের দূরত্ব বহুলক্ষ আলোকবর্ষ। কাজেই এই নীহারিকাপুঞ্জগুলি ছায়াপথের নক্ষত্রজগতের বহির্ভূত। ইহা মনে করিবার আর একটি কারণও আছে। বর্ত্তমানে জ্যোতিষীরা আকাশে কোন জ্যোতিষ্কের গতির বেগ গণনা করিতে সমর্থ। প্রায় প্রতি নক্ষত্রেরই আকাশে একটা গতি আছে। ছায়াপথজগতে নক্ষত্রের বেগ সেকেণ্ডে ৩০ হইতে ১২৫ মাইল পর্য্যন্ত হয়। আমাদের সূর্য্যের বেগ সেকেণ্ডে প্রায় ১২৫ মাইল। ইহা অপেক্ষা দ্রুততর বেগ ছায়াপথজগতে দেখা যায় না। কিন্তু শাদা নীহারিকাপুঞ্জের বেগ আরও অনেক বেশী। সম্প্রতি একটি নীহারিকা আবিষ্কার করা হইয়াছে, তাহার বেগ সেকেণ্ডে ৮ হাজার মাইল। এই সকল নীহারিকাপুঞ্জ যে ছায়াপথজগতের বহির্ভূত তাহাতে কোন সন্দেহ নাই। এই সকল নীহারিকাপুঞ্জের আলোকচিত্র হইতে ইহাদের সুন্দর অবয়ব জানা যায়। ইহারা দেখিতে এক একটি কুণ্ডলীর(spiral) মত। প্রত্যেকটির দুইটি শাখা একই সমতলে অবস্থিত, মধ্যস্থলে গোলাকার একটি মস্তক। একই বিন্দু হইতে আরম্ভ করিয়া দুইটি "৩" যদি লেখা হয় একটি উপর দিকে অন্যটি নীচের দিকে, তবে সেই ছবিটি অনেকটা কুণ্ডলী নীহারিকার (spiral nebula) মত দেখাইবে। দুই শাখাতেই তারা এবং কালো নীহারিকাপুঞ্জ বিদ্যমান। মস্তকটি ঘনসন্নিবিষ্ট তারার সমষ্টি।

প্রায় ২৫ বৎসর পূর্ব্বে জ্যোতিষী ইষ্টন্ কুণ্ডলী নীহারিকার সহিত ছায়াপথের নক্ষত্রজগতের সাদৃশ্য লক্ষ্য করিয়া বলেন যে ছায়াপথজগৎটি একটি কুণ্ডলী নীহারিকা ব্যতীত অন্য কিছু নয়। কিন্তু ইহার মস্তকটি কোন্ স্থানে অবস্থিত ইহা লইয়া যথেষ্ট মতভেদ হয়। সম্প্রতি এসম্বন্ধে একটি স্থির মীমাংসা হইয়াছে। ছায়াপথজগতের মস্তকটি ছায়াপথের সমতলেই অবস্থিত। পূর্ব্বে বলা হইয়াছে ছায়াপথের এক অংশ অতীব উজ্জ্বল, কিন্তু একটি কালো নীহারিকা দ্বারা দ্বিধাবিভক্ত। মস্তকটি ঘনসন্নিবিষ্ট তারার সমষ্টি এবং তাহা ঐ কালো নীহারিকার পশ্চাতে থাকায় আমাদের দৃষ্টির বহির্ভূত। ছায়াপথজগতে যত পদার্থ আছে তাহার প্রায় শতকরা ৯৯ ভাগ ঐ দিকে সন্নিবিষ্ট। কাজেই ঐ অংশটিই আমাদের নিকট অত্যুজ্জ্বল মনে হয়। অধিকন্তু ছায়াপথজগতে তারার গতি হইতে গণনা করিয়া দেখা গিয়াছে যে সমস্ত ছায়াপথজগৎটি কালো নীহারিকার পশ্চাদ্‌বর্ত্তী কোন বিন্দুর চতুর্দ্দিকে ঘুরিতেছে। পূর্ব্ব সিদ্ধান্তটি সত্য বলিয়া মনে করিবার ইহা একটি প্রবল কারণ। অন্যান্য অনেক কুণ্ডলী নীহারিকার আলোকচিত্র হইতে জানা যায় যে অনেকগুলির মধ্যস্থলে, কখনও উপরে বা নীচে কালো নীহারিকাপুঞ্জ বর্ত্তমান। কাজেই ছায়াপথজগতে এইরূপ কালো নীহারিকার অস্তিত্বে বিস্ময়ের কিছুই নাই।

ব্রহ্মাণ্ডের জিওগ্রাফি আলোচনা করিয়া জানা গেল যে সৌরজগৎ, নক্ষত্র—সকলই ক্ষুদ্র, নগণ্য জিনিষ। আমরা যাহাকে বৃহৎ নক্ষত্রজগৎ বলি তাহা একটি কুণ্ডলী নীহারিকা মাত্র। সৌরজগৎ ও অন্যান্য কোটি কোটি নক্ষত্র এই নীহারিকার অংশ মাত্র। মহাকাশে এইরূপ বহু কুণ্ডলী নীহারিকা ক্ষুদ্র দ্বীপের মত ভাসিতেছে। বর্ত্তমানে দুই লক্ষাধিক এইরূপ ক্ষুদ্র দ্বীপ-ব্রহ্মাণ্ড টেলিস্কোপের সাহায্যে আবিষ্কৃত হইয়াছে। তবু ইহাদের শেষ হইয়াছে বলিয়া মনে করিবার কোন কারণ নাই। ইহাদের পরস্পর দূরত্ব সম্বন্ধেও কতকটা ধারণা আমাদের আছে। মোটামুটি বলা যাইতে পারে যে একটি দ্বীপব্রহ্মাণ্ড হইতে নিকটবর্ত্তী দ্বীপব্রহ্মাণ্ডে আলো ১০ লক্ষ বৎসরে পৌঁছায়। এই দ্বীপগুলি শূন্যে স্থির হইয়া দাঁড়াইয়া নাই। ইহাদের গতি সম্বন্ধে জ্যোতিষী হাবল্ সম্প্রতি একটি সুন্দর নিয়ম পরীক্ষা দ্বারা আবিষ্কার করিয়াছেন। তিনি দেখাইয়াছেন যে প্রত্যেক চক্রাকার নীহারিকা প্রবল বেগে আমাদের নিকট হইতে দূরে অপসৃত হইতেছে। শুধু তাহাই নয়, প্রত্যেকে প্রত্যেকের নিকট হইতে দূরে যাইতেছে এবং প্রত্যেকটির

বেগ তাহার দূরত্বের অনুপাতে বাড়িতেছে। মনে হয় এই দ্বীপগুলি পরস্পর হইতে বিচ্ছিন্ন হইয়া মহাশূন্যের চতুর্দ্দিকে ধাবিত হইয়াছে এবং ব্যবধানের অনুপাতে ইহাদের বেগও বাড়িতেছে। এই অতীব রহস্যময় গতি জড়বিজ্ঞানের নিয়মের বিরোধী। বরং জড়-আকর্ষণের ফলে ইহাদের পরস্পরের সন্নিকটবর্ত্তী হইবারই কথা। আইনষ্টাইনের নূতন সাম্যতত্ত্ব (Principle of Relativity) এই রহস্যের এক মীমাংসা করিয়াছে। আইনষ্টাইনের মতে ব্রহ্মাণ্ড সসীম। মহাকাশের বিস্তৃতি প্রকাণ্ড হইলেও অসীম নয়। দৃষ্টান্তস্বরূপ আমরা গোলাকৃতি ফুটবলের রবার ব্ল্যাডারের দেহের কথা ভাবিতে পারি। ইহার দেহ সসীম অর্থাৎ দেহের যে কোন বিন্দু হইতে চলিয়া আবার সেই বিন্দুতে আসিয়া পৌঁছান যায়; সমস্ত দেহের ক্ষেত্রফলও (area) একটি অঙ্কদ্বারা প্রকাশ করা যায়। এই রবারের দেহে যদি কতকগুলি ক্ষুদ্র কালো বিন্দু আঁকিয়া ব্ল্যাডারটিকে ফুঁ দিয়া স্ফীত করা যায়, তবে দেখা যায় যে সকল কালো বিন্দুই কোন নির্দ্দিষ্ট বিন্দু হইতে এবং পরস্পর পরস্পরের নিকট হইতে সরিয়া যাইতেছে। অধিকন্তু প্রত্যেক বিন্দুর গতির বেগ সেই নির্দ্দিষ্ট বিন্দু হইতে তাহার দূরত্বের অনুপাতে বৃদ্ধি পায়। মোটের উপর বিন্দুগুলির গতি ঠিক কুণ্ডলী নীহারিকার গতির অনুরূপ। সাম্যতত্ত্ব অনুসারে মহাশূন্যের ধর্ম্ম এই ব্ল্যাডারটির মত। পার্থক্য শুধু ইহাদের আয়তনে (dimension)। ব্ল্যাডারটি স্ফীত করিলে যেমন তাহার ক্ষেত্রফল বাড়িতে থাকে, মহাশূন্যও সেইরূপ ক্রমশঃ স্ফীত হইয়া অবয়বে বৃদ্ধি পাইতেছে। স্ফীত হইবার দরুণ ব্ল্যাডারের দেহে কালো বিন্দুর ন্যায় কুণ্ডলী নীহারিকাগুলি পূর্ব্বোক্ত নিয়মানুসারে পরস্পর হইতে বিচ্ছিন্ন হইয়া পড়িতেছে। সাম্যতত্ত্বানুযায়ী গণনা যদি সত্য হয় তবে মহাশূন্য সসীম, কিন্তু ক্রমবর্দ্ধমান। অতীত কোন যুগে সম্ভবতঃ মহাশূন্য এবং তাহার যাবতীয় পদার্থ নিশ্চল ছিল, পরে কোন নৈসর্গিক কারণবশতঃ এক প্রলয়ের পর মহাশূন্য স্ফীত হইতে আরম্ভ করিয়া ক্রমশঃ বিস্তৃতি এবং ঘন-আয়তনে বৃদ্ধি পাইতেছে। ব্রহ্মাণ্ডের যাবতীয় পদার্থের গতি পরীক্ষাদ্বারা যে ফল পাওয়া যায় তাহার মীমাংসা বর্ত্তমানে কেবল ক্রমবর্দ্ধমান ব্রহ্মাণ্ডের পরিকল্পনা দ্বারাই সম্ভব। এই পরিকল্পনা বাস্তবের অনুযায়ী কিম্বা তাহার বিরুদ্ধবাদী, তাহা কেবল ভবিষ্যতে পরীক্ষা দ্বারাই স্থির হইবে।

শ্রীনিখিলরঞ্জন সেন

The Indian Ideal of Culture

By Sarat Chandra Roy (Ranchi).

The external culture of any people is only an expression of the mental ideal behind it. Geographic and economic environment, psychic accidents, social constraint, the intermixture of races and the contact of peoples and cultures and the imitative and borrowing propensities of man,—all these are active in varying degrees, either as stimuli or as methods in the total mental process that develops culture. The one fundamental fact in the evolution of culture is the continuous struggle, for satisfaction and achievements, for self-realisation, of the human mind or the 'social mind' if that term may be used, for all culture develops in society.

At every step of cultural progress, the dynamic element would appear to be the ideal behind it.

In the earliest stage of culture of which we can form any idea, when primitive man lived almost on the animal plane and his self-consciousness extended but little beyond his animal nature, his ideal of life was only the search for physical satisfactions. He was still mainly a creature of nature and depended on his natural environment for the satisfaction of his needs. Although the gross needs and impulses of his animal nature engrossed his mind and absorbed his energies, the idea of making himself master of his climate in order to maintain life was perforce pursued, and with the object of procuring food and shelter efficiently, families banded themselves into groups and, among some peoples, into clans.

The relatively most primitive tribes such as the Veddas of Ceylon, the Minkopis of the Andaman islands, and the Pygmy tribes of the Malay Peninsula and Africa exhibit the earlier steps of advance from nature to culture, in such contrivances as the construction of their leafy wind-breaks to protect themselves from the

inclemencies of the weather or the manufacture of rude implements and weapons to procure and prepare food or defend themselves against enemies. Essentially *Tāmasic,* this primitive culture exhibits traces of a *Rājasic* element as well.

When we pass from the primitive stage to the next higher stage of culture up to what is popularly known as 'barbaric' culture, the ideal still appears to be a gratification of the physical life, but the mental powers are requisitioned to contribute,—by invention, discovery and the practical application of gradually accumulated knowledge,—to the satisfaction of ever-increasing desires for physical comfort and happiness, leading to achievements of a higher economical type through increased control of physical environment. Although the ideal is still mainly that of mere domestic and economic human animal, the grossly perceptual world of primitive man is replaced partly by an ideational world. Ideas, standards, values gradually accumulate and develop culture—the growing social and traditional heritage of the community. Bands or clans grouped themselves into tribes, and, in course of time, tribes grouped themselves into nations. Though the *Tāmasic* and, next to it, the *Rājasic* elements predominate in this culture, glimmerings of the *Sāttvic* nature of man also appear.

In the civilized stage, the ideal gradually changes from a grossly commercial and economic to an intellectual, moral and spiritual one through increasing control not only over external nature but also over the lower nature of man himself. Thus great developments in science and arts, as also in altruistic ideas and philanthropic and religious movements, and wider interests and higher ideals are the achievements of civilized man.

The *Tāmasic* element has been brought more or less under control, and the other two elements—the *Sāttvic* and the *Rājasic* are mostly in evidence; and, as the temperaments of the peoples concerned differ, either the *Rājasic* or the *Sāttvic* element predominates among any particular people. According as either the one or the other *gūna* holds sway, the ideal varies,—the standard of intellectual, moral and spiritual values become different.

In Western countries generally, the standard of values is more

objective than subjective, more external than spiritual, more concerned with the senses than with the spirit, and material comfort and enjoyment is generally regarded more as an end in itself than as a means.

In ancient India, the standard of values was internal not external, subjective not objective, intellectual and spiritual not physical and material. The ancient Hindu ideal of culture was the realisation of the divine in man. The ancient Indian conception of human progress was "the increasing manifestation of the spirit in the gradual perfecting of its vehicles of Mind and Body." And the same traditional ideal is still cherished in modern India, although unfortunately no longer generally followed.

The embodiments of that ideal in ancient India were the *Rishis* of old. Plain-living, and high-thinking, benevolence and beneficence to all was their rule of life. The enlightenment of the intellect and the attainment of true knowledge through study and contemplation, the spiritual identification of the individual self with the universal self, an all-absorbing love for all that breathes and the dedication of one's mental and physical energies and material resources to the service of man,—these were the methods by which the ancient Indian *Rishis* sought to attain the goal of self-realisation and to fulfil the meaning of life. Nor were they unmindful of the necessity for progressive social adjustment to the changing conditions, and for assimilating all that is wholesome and helpful in the culture of other peoples with whom India might come in contact.

So long as India generally kept to that ideal and her leaders and teachers exemplified that ideal completely in their lives, her people stood in the forefront of the nations of the world. As that ideal began to grow dim and few followed in the footsteps of the venerable *Rishis* of old, India began to sink in the scale of nations.

Even to this day, however, the tradition persists. This is why even to this day the *Sadhu* and the *Pandit*—the saint and the sage, to whatever race or caste they may belong, are more honoured and revered in India than the rich and the mighty. Even in these degenerate days of India, some of her writers have written,

poets sung, and orators descanted on the beauty and necessity of the ancient Hindu ideal. But what modern India has so long needed most are concrete embodiments of that ideal in actual life. Such an ideal life modern India has found in Sir Prafulla's.

This venerable *Rishi* of modern India, old in age and wisdom but young in heart and energy, combines in himself all that is good and noble in ancient Indian culture with the best elements of Western culture which fit in with his native culture. This is why he is now the idol of Indian youth and has secured an abiding place in the hearts of all Indians, young and old.

A great scientist, a great educationist and inspiring teacher, a great industrial organizer, a great philanthropist and social worker, Sir Prafulla would be the pride of any country in the world. But greater than his science, greater than his teaching, greater than his industrial achievement, greater than his philanthropy and social work is his life. It is the life of an Indian *Rishi* of old—the ideal life of sweet simplicity and selflessness, plain-living, high-thinking and good-doing, with which Sir Prafulla has enriched and illumined India. He has translated into life the ancient Hindu ideal at a time when India has stood in greatest need of its revivification. May Heaven spare him long to guide Inida towards her destined goal !

A Peep into the Microscopic World

By Harendranath Ray (Calcutta).

(Plates XII-XV).

The world that we see before us without the aid of instruments of any type creates varieties of interest in us according to our own needs. It cannot be gainsaid that it is this curious interest in the world around that has made man score high amongst other living beings on this earth. Man's curiosity has goaded him to probe into the mysteries of Nature, which far from giving us a clue as to her dignified niceties has led us into a realm from where one finds it painful to retreat. So once being initiated into the virtuous methods of such findings one cannot but plunge heart and soul into the ocean of stupendous splendours of Nature, and enjoy the pleasure which is the sacred monopoly of a seeker of Truth. Such were the impulses perhaps which forced Leewenhoek, the great Dutch scientist during the earlier part of the seventeenth century, to devise a microscope and under it examine the wonders of the invisible world. Some of his observations stand unchallenged even to this day, inspite of the fact that modern methods are more sifting and tend to be scientifically precise. I remember once our great scientist Sir Jagadis Chunder Bose say in one of his lectures "a drop of water and a compound microscope unfold the mysteries of Nature before our eyes." Hundreds, thousands of them are there belonging to the microscopical world and perhaps it is beyond one's imagination even to reflect how many times one has to come to this world to get acquainted with each and every one of them. I therefore will let my readers know only that portion of the microscopical populace I have had special fortune to be acquainted with. These are minute animal organisms called Protozoa.

Protozoa are divided into four classes according to, broadly speaking, their method of locomotion and nutrition viz., Rhizopoda, Mastigophora, Ciliata and Sporozoa, and it is only a fragmentary portion of parasitic mastigophora, sporozoa and parasitic ciliates that I propose to deal with in this article.

Mastigophora for all practical purposes can at once be divided into two groups :—freeliving forms, and the parasitic forms. Again amongst the parasitic forms distinction is made between the haemoflagellates or blood flagellates well known examples of which are Kala-azar, Tropical sore in India and Sleeping sickness in Africa, and intestinal flagellates. Some of these intestinal flagellates e.g., Giardia and Chilomastix, when present in large

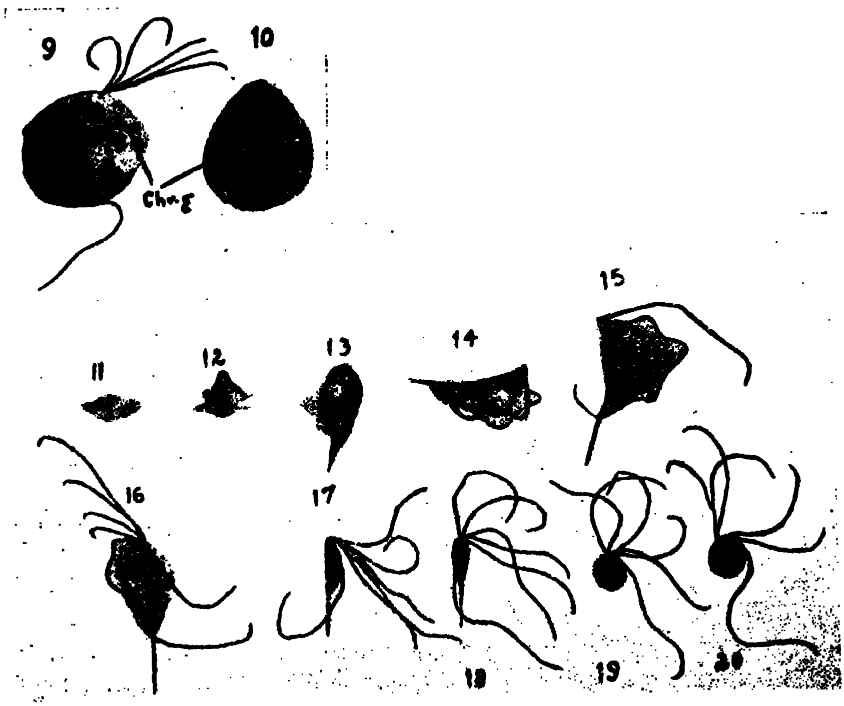


Fig. 1.—*Pentatrichomonas canis auri* Chatterjee, Ray and Mitra X 1800
9 & 10 represent rounded forms with numerous chromatic granules, Chr. g. are chromatic granules; 11 to 13 represent the plasmodium stages; 14 & 15 represent the flagella formed, but not differentiated; 16 represents the flagella differentiated; 17 to 20 represent minute organisms with 6 free flagella. (After Chatterjee, Ray and Mitra 1926. *Jour. Dept. Sci. Calcutta.*, vol. X).

numbers are said to produce pathogenic condition in human beings resulting in blood dysentery. Besides these, other flagellates such as *Pentatrichomonas bengalensis, Trichomonas hominis, Embadomonas intestinalis.*, etc., are also to be met with in the human intestine. Interest is also centered round similar forms encountered in lower animals, large number of invertebrates, fish, amphibians, reptiles, birds and mammals other than man. So there is not one group of animal which is free from some kind of protozoan invasion. Lateciferous plants are also known to harbour a type of flagellate called Phytomonas.[1]

The common intestinal form—*Trichomonas* has been studied in our laboratory. Its method of multiplication in culture is somewhat different from what has yet been described. Chatterjee, Ray and Mitra[2] (see text fig. 1.) in *Pentatrichomonas canis auri* have pointed out that some of the individuals become very much enlarged with large numbers of chromatic granules in them and it is from such forms that amoeboid forms are budded off which ultimately develop into adults. Later on in 1929 Chatterjee, Das and Mitra[3] studied the method of multiplication in *Pentatrichomonas bengalensis* and a Trichomonas from Mabuia (a lizard) and here again somewhat similar results were obtained (see text. fig. 2); somatella formation as observed by Kofoid and Swezy[4] in some trichomonad flagellates has been shown to hold good to certain extent, the only difference being that organelles are developed after

1 Only two species have been recorded from India by Row (Row 1915, *Trans. Grant Coll. Med. Soc.*, Bombay), and it now awaits the attention of future workers to make a systematic survey of this group. Hemipteran bugs that suck the juice of such plants are said to transfer these flagellates to them and in certain extreme cases are known to produce pathogenic conditions. Great deal of controversy, however, is there regarding the mode of transference, and enthusiastic workers are suggested to take up this problem in India.

2 Chatterjee, Ray and Mitra 1926.—Notes on *Pentatrichomonas canis auri*. n. sp., *Jour. Dept. Sci.* (Calcutta), vol. 8.

3 Chatterjee, Das and Mitra 1929.—On the method of multiplication of Pentatrichomonas and Trichomonas and the origin and development of their organalles. *Jour. Dept. Sci.* (Calcutta), vol. 10.

4 Kofoid, C. A. and Swezy, O. 1915.—Mitosis and multiple fission in Trichomonad flagellates, *Proc. Amer. Acad. Arts. and Sci.*, 51.

the individual units have separated as amoeboid forms from the somatella. Investigations on these lines are still going on in our laboratory and every time we culture trichomonas from any vertebrate host we come across "giant" forms full of chromatic granules and very minute amoeboid forms with just a trace of chromatic line from which organelles are finally seen to develop.

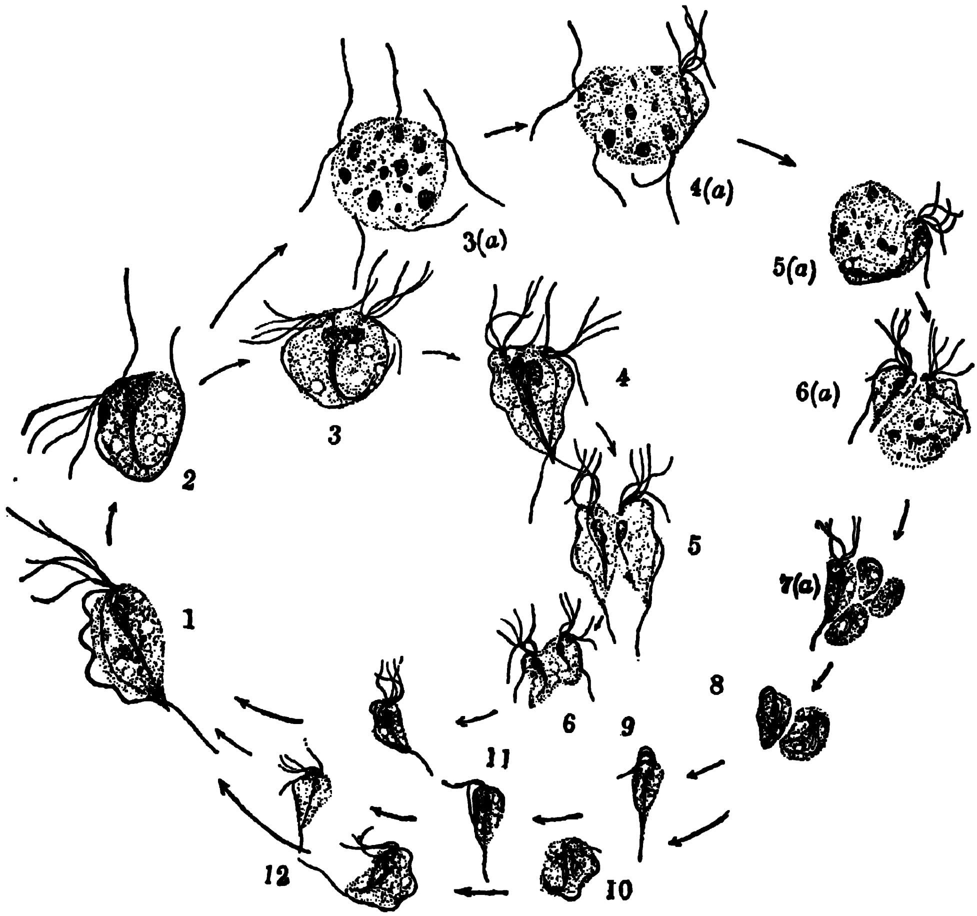


Fig. 2.—Diagrammatic representation of method of multiplication of *Pentatrichomonas bengalensis*.

1, adult Pentatrichomonas; 2, rounded form of the same; 3, 4, 5 and 6, ordinary method of multiplication by binary fission; 7, an individual after division; 3a, multiple division (somatella); 4a, a somatella with a gemmule; 5a, a somatella with two gemmules, one in plasmodial stage and the other in flagellated stage; 6a, separation of the gemmules; 7a and 8, further stages in separation of gemmules; 9, 10, 11 and 12, separated individuals from the somatella developing into adult forms. (After Chatterjee, Das and Mitra).

The cellulose eating termites or white ants have varieties of flagellates in their intestine and at present a systematic survey of their intestinal fauna is being made in our laboratory. It may be remarked here that Cleveland's experiments have proved these flagellates to be responsible for the digestion of cellulose in the intestine of termites.

Protozoa belonging to the class sporozoa are solely parasitic and produce resistant spores, except where an intermediate host intervenes, e.g., malaria parasite, in order to inflict fresh infection. Broadly speaking sporozoa can be classed under two heads, Gregarines and Coccidia. Amongst Gregarines again organisms can be classed under two subdivisions, (1) true Gregarines or Eugregarines and (2) Schizogregarines. Eugregarines are further divided into two tribes, (i) cephaline and (ii) acephaline according to the presence or absence of an organ of attachment or epimerite at one end of the organism. A number of cephalines were studied by Professor Mackinnon of King's College, London, and the author[5] and varieties of epimerites in those forms (see Pl. XII, figs. 1-7) have led them to suggest that these gregarines form a heterogenous group. *Hentschelia thalassemae* Mackinnon and Ray, from *Thalassema neptuni* Gärtner, a marine worm, establishes its connection with the host cell in a manner which is quite unlike any other gregarine. The infected host cell is bodily dragged out of the epithelial lining and serves the purpose of anchoring the parasite to the intestine of the host (see Pl. XII, fig. 7). Again epimerite in *Polyrhabdina spionis* is neither intracellular nor amoeboid as has been held by previous workers but is simply a means to hold on to the host cell. A cephaline gregarine has been studied by the author jointly with Mr. M. Chakravarty (in press) and here too it has been pointed out that an epimerite, consisting of about eight pairs of prongs, is used as an organ to hold the host cell. A very interesting thing has recently been noted by the author in *Lankesteria culicis* from a mosquito *Aedes* (*Stegomiya*)

5 Mackinnon, D. L. and Ray, H. N. 1931.—Observations on Dicystid gregarines from marine worms. *Quart. Jour. Micros. Sci.*, vol. 74.

albopictus in Calcutta—a gregarine at an early stage, if happens to come in contact with a cell with thin chitinous lining penetrates it bodily and grows intracellurly while one coming in contact with thick and frilled chitinous lining grows extracellurly and develops an epimerite.[6] Perhaps these few examples would be sufficient to convey to my readers an idea how these parasitic forms have their hosts in their "claws." In acephalines this organ is not marked. The story does not end here. They grow, in many cases at the expense of the tissue of the host, till they have attained maturity and then enter into the next phase of the life-history known as *sporogony*. This stage is initiated by coming together of two mature forms, now called gametocytes. Association is brought about in different ways in different gregarines—in *Lecythion thalassemae* Mack. and Ray, and *Hentschelia thalassemae* Mack. and Ray it is lateral (see Pl. XII, fig. 8), in a gregarine from a millipede recently studied by the author and Mr. Chakravarty (in press) the gametocytes interlock themselves by a couple of blunt pseudopodic processes formed at their hind ends for this purpose. Again in many cases they come together by their anterior ends. After the association is well established a protective wall is secreted round them and the nucleus of each gametocyte by repeated binary division gives rise to large number of nuclei which arrange themselves at periphery of their protoplasm. Each of these nuclei surrounded with a portion of protoplasm, now called gametes, are budded off from each gametocyte and fuse in pairs. In most gregarines gametes formed from one gametocyte cannot be distinguished from that of the other. Fusion between such gametes is known as *isogamy*. But fusion between unequal gametes or *anisogamy*, which is the characteristic of Coccidia, is not altogether unknown in gregarines. In two species of *Stylorhynchus* described by Léger and Duboscq,[7] one type of

6 This work is under preparation and the details will soon be published elsewhere.

7 Léger and Duboscq 1904.—La reproduction sexueé chez les Stylorhynchus. *Arch. Prot. Bd.*, 4.

gamete called male is active and bears a flagellum at its hind end, while the other type or female is round and inactive. In a gregarine from *Thalassema* Mackinnon and Ray also noticed anisogamy but here the flagellum of a male gamete was placed at the anterior end, a feature which is in agreement with cases where anisogamy is the rule in sporozoa. Whatever may be the case, isogamy or anisogamy, gametes fuse in pairs completely forming a zygote. This is the beginning of the formation of resistant spores. Each zygote secretes a protective covering and its nucleus, by three successive divisions, gives rise to eight nuclei. These eight nuclei portion off a bit of protoplasm round each and assume sickle-shaped structures called sporozoites. The whole process, beginning from association to spore formation, is known by the term *Sporogony*. Sporogony may either take place inside the intestine of the host or after association the gametocysts come out to the exterior with the excreta and develop spores there, provided sufficient amount of moisture is present. Spores are produced in large numbers and are the infecting agents. They, if happen to be swallowed by their hosts, burst in the intestinal canal, release the sporozoites, and start fresh infection. It is interesting to find that the relation between the host and the parasite is specific.

It is a well established fact that the number of chromosomes in the nucleus for a particular species is always constant and whereever sexual union occurs the gametes always contain half the normal or haploid number so that the offspring, which results from their union, comes to possess again the normal number. But in sporozoa, as far as it is known, a nucleus possesses haploid number throughout its existence, the normal number being restored only for a short time when the gametes fuse to form a zygote. In a gregarine from *Thalassema neptuni*, Mackinnon and Ray have shown this to be true and the haploid number indicated there is three (see text fig. 3A, a, b, c, d). Life-histories of malaria parasites, which belong to sporozoa, require re-investigation from this point of view.

Now to turn our attention to Schizogregarines—they differ from other gregarines in having a process of schizogony or asexual

mode of multiplication intercalated in their life-history. It is for this reason alone that this group is considered to link Gregarines

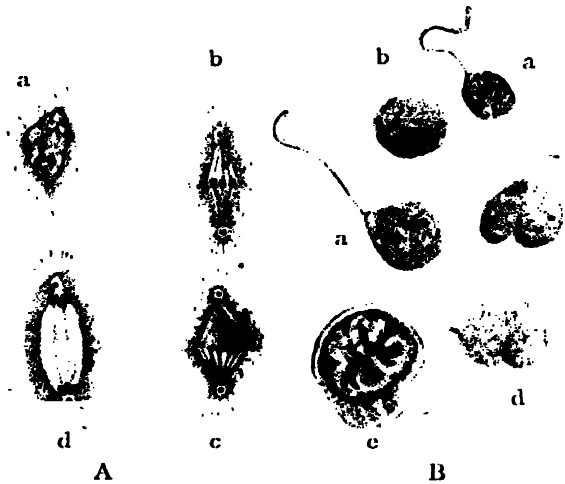


Fig. 3.—A, a, b, c and d, four stages in the division of nuclei in an older gametocyst. From a section. In two of the figures it can plainly be seen that the number of chromosomes at this stage is three. X 2,100.

B, living gametes: a, flagellated male gametes; b, passive female gamete; c and d, copulae; e, ruptured sporocyst showing the eight sporozoites. X 1,800.

with Coccidia although morphologically there is a great deal of difference between them. While working in the Marine Biological Station, Plymouth, I came across a group of Schizogregarines which belong to the genus Selenidium.[8] The genus Selenidium was founded by Giard in 1864 for a gregarine with pendular movement found in the body cavity (later on shown by Caullery and Mesnil[9] to be in the intestine) of Nerine, an annelid worm. Brasil[10] in 1907 further defined Selenidium as a Schizogregarine with intracellular schizogony and having longitudinal myonemes along the whole length of the vermiform body. They are chiefly confined

8 Ray, H. N. 1930.—Studies on some sporozoa in Polychaete worms, I Gregarines of the genus Selenidium. *Parasitology*, vol. 22.

9 Caullery and Mesnil 1899.—Quelques parasites internes des annelides. *Trav. Stat. Zoology*, Wimereux, 7.

10 Brasil 1907.—Recherches sur le cycle évolutif des Selenidiidae, grégarines parasites des annélides polychètes. I. La schizogonie st la croissance des gamétocytes chez. *Selenidium caulleryi* n. sp., *Arch. Prot. Bd.*, 8.

to the intestine of Annelid worms and are acephalines, that is, do not possess any special organ of attachment. I had the fortune to examine ten species of selenidium from different marine worms of which five were new to the science. Only two species, *S. caulleryi* and *S. mesnili* (see Pl. XIII, fig. 27) were found to conform strictly to the definition of the genus selenidium as defined by Brasil, while all others, as far as the author has been able to follow, are innocent of schizogony either extracellular or intracellular. Regarding this the writer is of opinion that the development of schizogony is, in some way, definitely associated with increase in the intracellular habit. If that be the case then *S. mesnili* or *S. caulleryi* which are intracellular for greater part of their life-history are more specialised than selenidium from *Scolelepis fuliginosa* which, therefore, may be regarded as the more old-fashioned and the less specialised in their behaviour. In all of them at all stages the presence of chromatic bodies has been indicated at the anterior end. Those are usually thread-like, sometimes club-shaped, but always of a definite type and length in any one species and usually pretty constant in number (see Pl. XIII. figs. 15-26). It is quite probable that the diagnostic value of these structures was not appreciated by the previous workers.

Association in these gregarines, as far as I have studied them, takes place by their posterior ends. The nucleus of each gametocyte behaves in a manner somewhat different from what has been described above—large number of nuclei are formed inside the mother nudlear membrane (see Pl. XIV. fig. 29), which after being fully formed travel towards the periphery (see Pl. XIII. fig. 28). This phenomenon has been seen to hold good in cases of *Selenidium caulleryi* Brasil, *S. spionis* (Kolliker). *S. foliatum* Ray, *S. potamillae* Mackinnon and Ray (in press), and *Meroselenidium keilini* Mackinnon and Ray (in press).

Very little was known about the spore formation in selenidium till the author pointed out the method of obtaining them.* About a dozen worms after being thoroughly cleaned were kept in sea-

* For details see foot note 8.

water which was constantly aerated and within 48-60 hours gametocysts were picked up from the debris surrounding the worms. Spores of *S. spionis* and *S. foliatum* from the marine worm *Scolelepis fuliginosa* differ from each other in having four and eight sporozoites respectively (see Fl. XIV. figs. 30, 31). But as the number of sporozoites in a spore is generally considered a character of some importance in determining the affinities of sporozoa within a group, it has been suggested by the author that the genus selenidium may have to be subdivided on this ground, if on no other. In a marine worm *Potamilla reniformis* the author and Professor D. L. Mackinnon have elucidated the life-history of two gregarines (in press) and there on this ground, besides other minor features, they have created a new genus Meroselenidium to receive one of them with spores containing innumerable sporozoites, while the other belonged to selenidium with four to ten sporozoites. A thorough revision of this genus, however, is necessary before one can be definite about its relative affinities to other sporozoa.

In the intestine of *Scolelepis fuliginosa* containing *Selenidium spionis* and *Selenidium foliatum* the author came across another sporozoa which belonged to Coccidia. The life-history of this coccidia was unfortunately mixed up with that of two selenidium found along with it by Caullery and Mesnil in 1901.[11] About these selenidium they say, "La parasite intracellulaire, d'abord en forme de croissant, prend peu à peu la forme sphérique; en meme temps son noyau se multiple, la sphére se resout en nu barillet schématique de 7-8 μ de hauteur et composé d'une douzaine d'éléments avec un petit reliquat polaire. Les mérozoites ainsi formés se séparent, tombent dans la luminaire de l'intestine, s'accolent par la pointe aux cellules intestinales etcroissent en restant extracellulaire. Nous avons suivi cette évolution en detail et sans lacunes. Cette observation confirm l'existence de la schizogonie intracellulaire dans cette

11. Caullery and Mesnil 1901.—Le parasitisme intracellulaire et la multiplication asexuée des gregarines. *Compt. Rend, Soç. Biol.*, Paris, vol. 57.

group des Grégarines." Asexual method of multiplication or schizogony is the *rule* amongst coccidia and it was this portion of the life-cycle which those authors considered to be the part of the history of selenidium. It apparently never occurred to them that other sporozoa could also live side by side in the same host. To receive this coccidian the author created a new genus Dorisiella in 1930 and called it *Dorisiella scolelepidis.*[12]

The parasite grows intracellulally (see Pl. XIV. fig. 32) and when it has attained a certain size its nucleus begins to divide, the result of which is the production of large number of small bodies called merozoites (see Pl. XIV. figs. 33-35). The host cell now gives way and the merozoites thus liberated in the lumen of the intestine attack fresh epithelial cells (see Pl. XIV. fig. 36). Some of these merozoites may repeat the schizogonic cycle while others become differentiated into macrogametocytes or females and microgametocytes or males (see Pl. XV. figs. 37 and 38). At all stages of development a number of deeply staining granules can be distinguished at the anterior pole of the parasite which the author is inclined to think to be of nuclear origin. The females or macrogametocytes after attaining certain size drop off the epithelial cells and repenetrate that portion of the gut epithelium where the male gametes are being developed (see Pl. XV. figs. 38 a, b. c and 41). This is a very peculiar phenomenon, because in all other known coccidians the macrogametocytes are inert. The formation of male gametes is initiated by schizogony of the microgametocytes (see Pl. XV. figs. 39 and 40). This is called microschizogony to distinguish it from macroschizogony or ordinary schizogony in this coccidia (described above). The resulting micromerozoites are eight in number which soon break away from the main mass and come to lie at random in the epithelial cells (see Pl. XV. figs. 42 and 43). The nuclear material or chromatin of these micromerozoites now become very loose and give rise to very minute bodies shown in Pl. XV. fig. 44. What actually is the process of fertilisation I

12 Ray, H. N. 1930.—Studies on some sporozoa in Polychaete worms, II. Dorisiella scolelepidis n. gen., n. sp. *Parasitology*, vol. 22,.

unfortunately cannot say but bodies shown in Pl. XV. fig. 45* are perhaps swollen male gametes which fuse with the female gamete nuclei and form zygote. Here the haploid number of chromosomes is three. Oocyst or a protective covering, so characteristic of other coccidia, is not found in the present-case. The zygote now divides to form two sporoblasts within each of which develop eight sporozoites (see Pl. XV. figs. 47 and 48). All those processes take place within the host cell and that is perhaps why the oocyst is not developed. The parasitised host cell finally gives way and the mature spores are thus carried to the exterior with the faecal matter of the worm. Large number of these worms live together in the mud and their gregarious habit is responsible for heavy infection. Coccidiosis or pathogenie conditions due to coccidia is not uncommon in poultry and domestic animals and a systematic account of such parasites would be of great help to poultry farms in our country.

Now I shall tell my readers something about Myxosporidia, parasitic in fish, reptiles and amphibians which is of great economic importance from the point of view of pisciculture in our country. In trying to make a systematic survey of myxosporidia from local edible fishes the author came across several genera not recorded from India before (see "Nature" 1932. Vol. 130, p. 99). *Gobious rubicundus* was found to be infested with a species of Ceratomyxa and under laboratory conditions this infection proved to be fatal. The author is inclined to think that in a confined area of water fish mortality due to myxosporidian infection is not altogether an impossibility. Here too the infection is set up by spores, the size and shape of which vary in various groups. The seat of infection, invariably, is the gall bladder but other organs are also subject to infection. In extreme cases no organ is free from such invasion. The spores are characterised by the presence of polar capsules in them, the number of which again varies with the group. Ordinarily if a spore is swallowed by a host the sporoplasm, confined within it, is liberated by the bursting of the spore as a result of the action of the digestive juices. Polar capsules respond quickly to this action by darting off filaments by means of which the spore is

anchored to the host cell till the sporoplasm has got access to the epithelial cell of the host. This sporoplasm gradually reaches its seat of infection and by repeated multiplication of its nuclei together with the increase in the amount of its protoplasm now assumes an amoeboid form called *plasmodium*. By a series of complicated processes spores are formed in these plasmoda and ultimately released from the parent body. Spores of the myxosporidia infesting the appendages of the digestive tract are expelled to the exterior with the faecal matter, while those attacking the kidney, generative organs follow the course of such organs, and again, those inhabiting the gill filaments are directly thrown into the water, to bring about fresh infection. It is quite apparent, therefore, that chances of spreading the infection is much more favourable in a confined area of water than in a running stream. Investigations on these parasites are now going on in the Zoological laboratory of the University of Calcutta, the results of which will soon be published elsewhere.

A few words about ciliates and I shall close. Large number of these protozoa are free-living and are found in any stretch of water, starting from the Tala filter water tank down to sewer water one is apt to find some sort of ciliate there. Again there are certain forms which are parasitic either in vertebrate or invertebate host. Most dangerous of these parasitic forms is *Balantidium coli* which infests the human intestine and sometimes produces ulceration in the large intestine. Fortunately enough this parasite is not of very common occurrence in our country. While examining the gut contents of frogs for such ciliates the author encountered a Balantidium with a boring apparatus situated at its anterior end. In sections of the infected portions of the gut this apparatus was seen to be embedded in the epithelial lining. It is by the activity of this borer that this ciliate produces a wound and feed on the red blood corpuscles which flow therefrom. Now Balantidium has for a long time been known to be guilty of feeding on blood corpuscles and penetrating into the gut wall, but this is the first time that any mechanism to fulfil such a purpose has been discovered. I have called it *Balanti-*

dium sushilii and the details will soon appear elsewhere (in press). Since, I have examined several species of Balantidium from frogs and all of them are found to possess a boring apparatus at the anterior end. It, therefore, appears that this structure is of a more common occurrence than thought to be, and it would certainly be interesting to see what the affairs are in the human Balantidium.

Above is, indeed, a very very fragmentary account of certain types of parasitic protozoa by whcih I have attempted to convey to my readers some idea as to how complexly they are organised and what world of mysteries are still there to be solved. Things of economic importance to a biologist are not a "made to order" affair but are results of his laborious searches which may ultimately benefit the humanity. But the vision of a seeker of Truth should be above all those things and go for Truth alone, and not after its applications.

EXPLANATION OF PLATES XII-XV.

All figures in Plate XII are taken from "Observations on Dicystid Gregarines from worms" by D. L. Mackinnon and H. N. Ray, in *Quart. Jour. Micros. Sci.* Vol. 74, 1931, and in plates XII-XV they are from "Studies on some sporozoa in Polychaete worms, I Gregarines of the genus Selenidium, and II Dorisiella scolelepidis n. gen., n. sp." in *Parasitology.*, Vol. 22., 1930. In plates XIII-XV, the magnification is 2100 unless otherwise mentioned.

Plate XII.

Fig. 1.—*Polyrhabdina spionis*, Trophozoite. Drawn from a smear. X 350. n. var. *bifurcata*.

Fig. 2.—*Polyrhabdina spionis*. Epimerite of the gregarine attached to the epithelium. The nearer wall has been shaved away in the section. X 1,400. n. var. *bifurcata*.

Fig. 3.—*Polyrhabdina polydorae* (?). Epimerite, showing detail of structure. X 1,400.

Fig. 4.—*Lecythion thalassemae*. Mature trophozoite, attached to the epithelium. From a section. X 400. n. gen. n. sp.

Fig. 5.—*Lecythion thalassemae*. Epimerite of a full-grown gregarine, greatly enlarged to show detail of structure. Note the method of attachment to the epithelial cell (celia omitted). X 1,400.

Fig. 6.—*Hentschelia thalassemae*. Mature trophozoite. Form a smear. Note the intracellular epimerite. X 350.

Fig. 7.—*Hentschelia thalassemae*. Young intracellular trophozoite. From a section. Note the hypertrophy of the host-cell and its projection into the lumen of the gut. X 1,000.

Fig. 8.—*Hentschelia thalassemae*. Associating gregarines. Note that one still retains its intracellular epimerite. The nuclei are elongating. From a smear (striations omitted). X 500.

Plate XIII.

Fig. 15.—*Selenidium caulleryi* Brasil. Young trophozoites. Note the thread-like structures at their anterior ends. (Longitudinal striations are only shown on one).

Fig. 16.—*S. mesnili* Brasil. A full-grown trophozoite. Note the club-shaped intracytoplasmic bodies at its anterior end. Drawn from a smear fixed in Schaudinn's fluid.

Fig. 17.—*Selenidium spionis* (Kolliker). Young trophozoite. Drawn from a smear.

Fig. 18.—*S. spionis*—only the anterior end of an adult shown.

Fig. 19.—*S. foliatum* n. sp. Young intracellular stage. Note the chromatic threads at the anterior end, which is directed towards the base of the epithelial cell.

Fig. 20.—*S. branchiommatis*. Anterior end magnified to show the chromatic thread-like bodies.

Fig. 21.—*S. sabellae*. Anterior end of the same, showing the dark staining thread-like bodies in the epimerite.

Fig. 22.—*S. terebellae*. Young trophozoite showing the thread-like *structures*. Drawn from a smear.

Fig. 23.—*S. alleni* n. sp. Trophozoite. (X 1000).

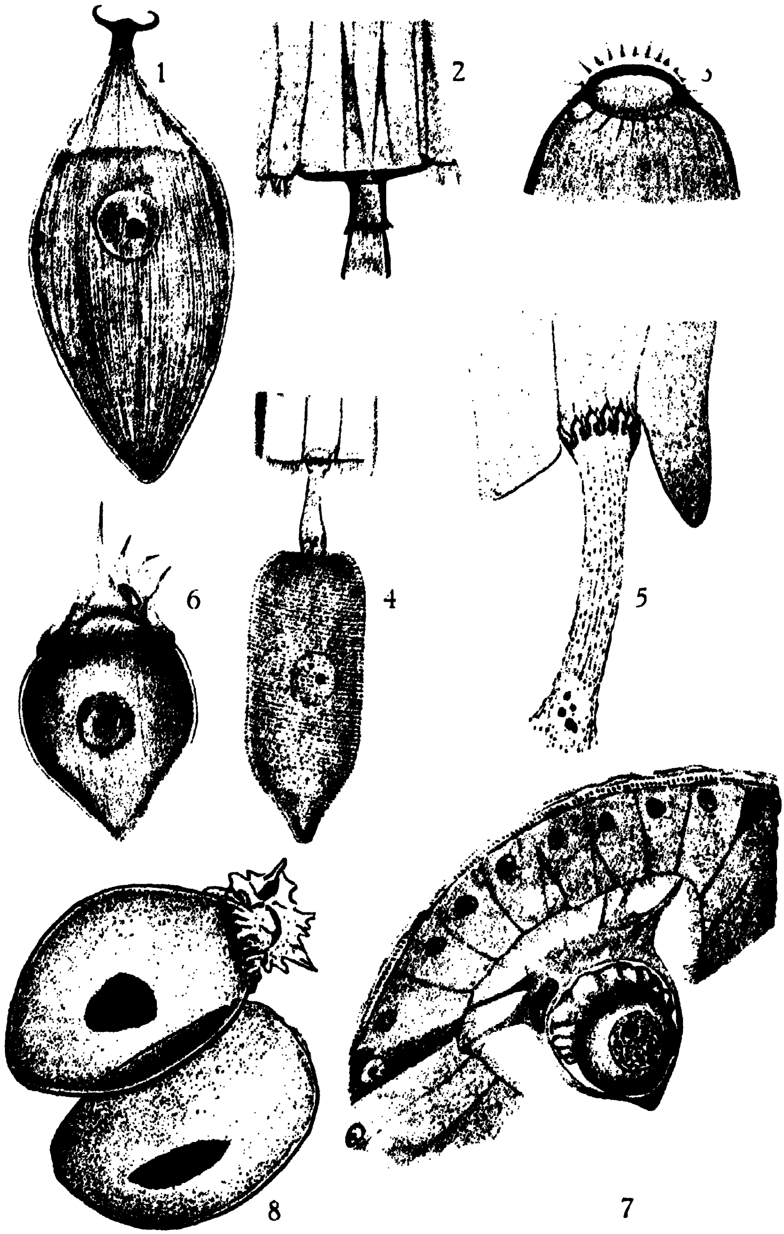
Fig. 24.—*S. alleni*. Anterior end of trophozoite. (X 2100).

Fig. 25.—*S. alleni*. Young trophozoites. Drawn from a section of the intestine of Branchiomma.

Fig. 26.—*S. brasili*. Anterior end, showing the thread-like structures.

Fig. 27.—*S. mesnili*. A schizont, with numerous nuclei. Drawn from a section of the intestine of Myxicola infundibulum. (X 500)

Fig. 28.—*S. caulleryi*. Advanced gametocyst. Note the outline of a parent nucleus which is still persisting. Reconstructed from four sections.



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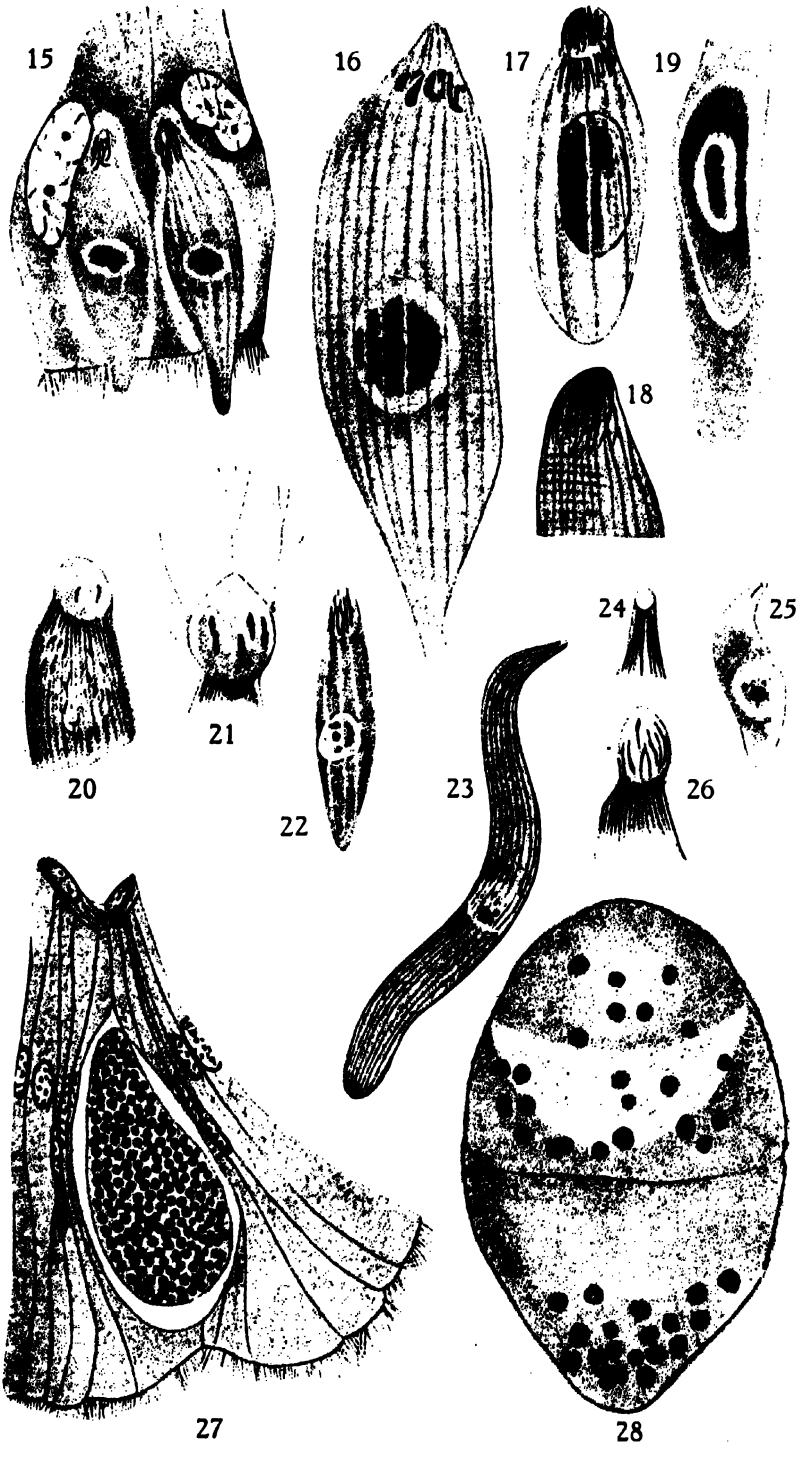

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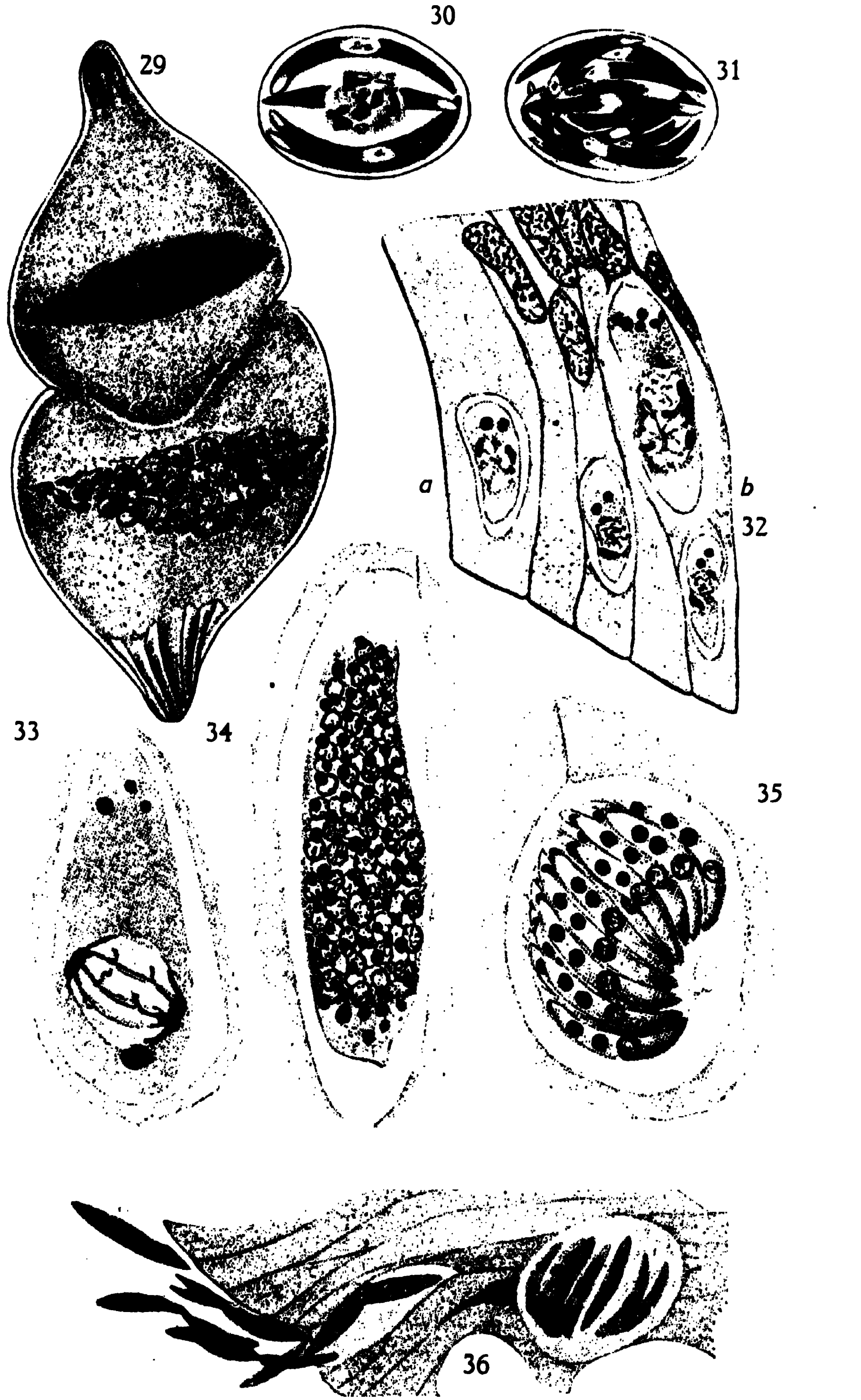

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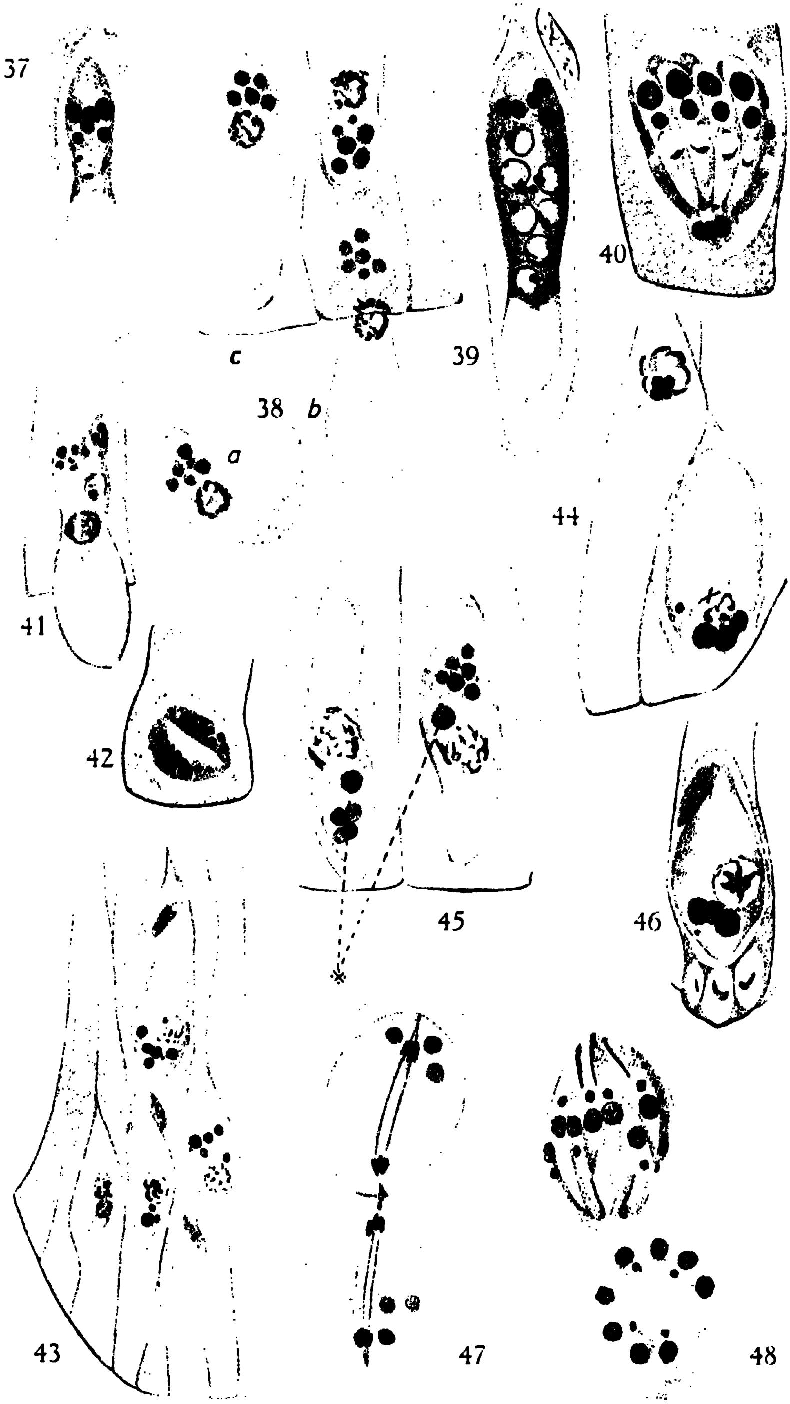

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Plate XIV.

Fig. 29.—*S. caulleryi*. Association. The intracytoplasmic thread-like structures are shown only in one of the pairs, while in the other the longitudinal striations are indicated. Note small spindle-like bodies within one and vesicular bodies, the gamate nuclei in the other.

Fig. 30.—*S. spionis*. A fully formed spore, with four sporozoites. Note the residual mass of protoplasm and the refringent area at one of the ends of the sporozoites. Drawn from living material.

Fig. 31.—*S. foliatum*. A fully developed spore. Note the residual mass of protoplasm in its centre. Drawns from living material.

Fig. 32.—Schizonts of *Dorisialla scolclepidis* Ray, in the epithelial cells of the intestine (a) young, (b) with two nuclei.

Fig. 33. Schizont. A nuclear spindle showing the V-sahped chromosomes at anaphase. Eote the chromatic blob on one side of the spindle. (X 4200).

Fig. 34.—Schizont with numerous nuclei. Note the old chromatic granules lying towards the clearer end of the schizont.

Fig. 35.—Group of macromerozoites.

Fig. 36.—Macromerozoites escaping into the lumen of the gut (X 1000).

Plate XV.

Fig. 37.—Microschizont. Note the "Waist" and the vacuolar area behind the nucleus.

Fig. 38.—Female parasite (a) free in the lumen of the gut and on its way to enter a cell, (b) entering an epithelial cell, (c) after entering the cell; note the tail-like posterior end at this stage.

Fig. 39.—A microschizont with eight nuclei. Note the chromatic granules at the anterior end and the clear vacuolar area at the posterior. X 2500.

Fig. 40.—A group of micromerozites. X 2500.

Fig. 41.—Female parasite entering a cell containing a micromerozoite.

Fig 42.—Two micromerozoites, showing the nuclei with diffuse chromatin. X 1600.

Fig. 43.—A portion of the section of the wall showing three mature females and one micromerozoite. (X 1050).

Fig. 44.—A portion of the section of the gut wall showing a group of microgametes and one female.

Fig. 45.—Mature female gametoxytes containing peculiar bodies (* refers to the supposed microgametes in the neighbourhood of their nuclei).

Fig. 46.—Three microgametes (?) lying in vacuoles in front of a female.

Fig. 47.—Twin sporoblasts showing the nucleus at anaphase. Note the equal distribution of intracytoplasmic chromatic granules and the development of the sporocysts.

Fig. 48.—Fully formed spores with eight sporozoites. One spore is shown in transverse section.

India as known to Panini

By Radha Kumud Mookerji (Lucknow).

Pāṇini's grammar throws some light on the history of its times. His date was thought to be earlier than 700 B.C. by Goldstuecker on the ground that he was acquainted only with the three Vedic Saṃhitās and the *Nighaṇṭu* (Yāska's *Nirukta*). Sir R. G. Bhandarkar was for the same date on the ground that Pāṇini does not show much acquaintance with the Deccan. According to Macdonell [*India's Past,* p. 136], "the date of Pāṇini is usually assumed to be about 350 B.C. but the evidence for this is very doubtful : it is perhaps safer to say that he lived after, probably soon after, 500 B.C."

Pāṇini's geographical horizon extended to Kaliṅga [IV. 1, 70] in the East, to Asmaka [IV. 1, 173] in the South, to Sindh [IV. 3, 32] and the Cutch [IV. 2, 133] in the West and to Taxila [IV. 3, 93] and the Swat Valley [IV. 2, 77] in the North-West. The different regions or provinces were called *Janapadas,* of which he mentions 22, including Kekaya [VII. 3, 2], Gandhāra [IV. 1, 169], Kāmboja [IV. 1, 175], Madra [IV. 2, 131], Avanti [IV. 1, 176], Kuru [IV. 1, 172; 2, 130], Śālva [IV. 1, 173], Kośala [IV. 1, 171], Bhārata [IV. 2, 118; VIII. 3, 74], Uśīnara [IV. 2, 118], Yaudheya [IV. 1, 178], Vṛji [IV. 2, 131] and Magadha [IV. 1, 170]. Besides these, Pāṇini refers to *Prācya Janapadas* [IV. 1, 178] or eastern provinces which, according to *Kāśikā,* comprised Pancāla, Videha, Aṅga and Vaṅga.

These states were named after their Kṣatriya peoples [IV. 1, 168]. Their Kṣatriya rulers were called *Jānapadins* [IV. 3, 100]. The citizens of the same state or *Janapada* were called *sajanapadāḥ* [VI. 3, 85]. As the state was represented in the ruler, loyalty to the state was synonymous with loyalty to its ruler

[IV. 3, 100]. There was thus a lively sense of patriotism in those days.

The different *Jānapadas* or states were separated by well-defined boundaries [IV. 2, 124].

Below the *Jānapada* were administrative divisions called *Viṣaya* [IV. 2, 52], *Nagara* and *Grāma*. A village was named after its *Grāmaṇī* [V. 2, 78].

Pāṇini refers to Ṛgveda [VI. 3, 55], Sāmaveda [I. 2, 34] and Yajurveda [II. 4, 4]; to the Śākala Śākhā of the Ṛgveda [IV. 3, 128], its *padapāṭha* [VI. 1, 115] and *kramapāṭha* [IV. 2, 61] and its divisions into sūktas, adhyāyas, and anuvākas [V. 2, 60]; to the Kāṭhaka recension of the Black Yajurveda [VII. 4, 38].

He knows of Brāhmaṇa works and refers to two containing 30 and 40 adhyāyas [V. 1, 62] supposed by Keith to be the Aitareya and Kauṣītakī Brāhmaṇas.

He mentions chhandas works of Ṛṣis like Tittiri, Varatantu (whose disciple, Kausta, was of Yāska's time), Kaśyapa and Kauśika, Śaunaka, of Kaṭha and Charaka, Kalāpi and Chhagalin, of the pupils of Kalāpi and Vaiśampāyana [IV. 3, 101-109].

As regards Sūtras, he knows of *Kalpa* sūtras [IV. 3, 108] of ancient authors (purāṇaprokta) and mentions recent works like the Bhikṣu sūtras of Parāśara and Karmanda and the Naṭa sūtras of Śilālin and Kṛśāśva [IV. 3, 110-111].

He knew of a wide variety of secular literature comprising dramas [e.g., *Śiśukrandīya* in IV. 3, 88], *Ślokas* [III. 1, 25] *Gāthās, Kathā* [IV, 4, 102] or *Mahābhārata* [VI. 2, 38].

He knew of the literature of *Vyākhyāna* or commentary such as works giving details of *puroḍāśa* [IV. 3, 70], grammatical works dealing with nouns (nāma) and verbs [IV. 3, 72], chhāndasa works and those called *Ārchika* (relating to hymns) or *Ādhvarika* (relating to sacrifices).

All these various works are classified by Pāṇini under (1) *Dṛṣṭa* (revealed, i.e. *Śruti*) (2) *Prokta* (compiled or enounced, i.e., secondary works) (3) *Upajñāta* and *Kṛta* (originated and composed) and (4) *Vyākhyāna* or explanatory works.

The ceremony of initiation was called *Āchārya karaṇa* [I. 3, 36]. The pupil was called a *chhātra* because he was protected from all evil by his teacher [IV. 4, 62]. Pupils of the same teacher were called *satīrthyas* and *sabrahmacāriṇas* [VI. 3, 86]. They are named after their teachers e.g., Pāṇinīyas [VI. 2, 36], or, after their subjects of study, such as Vedic Kratus, Ukthas and Sūtras [IV. 2, 59-60].

The ordinary term for a teacher was *Adhyāpaka*. The specialist in Vedic recitation was called a *Śrotriya* [V. 2, 84] and in Vedic discourse and interpretation (*pravachana*) a *Pravaktā*. One charaṇa might follow the system of recitation of another charaṇa [II. 4, 3]. A teacher usually repeated the text five times. A pupil learning it from a single recitation was called *Ekasandha-grāhī* [V. 1, 58]. Pupils were graded according to the number of mistakes they committed in such Vedic recitation, the limit allowed for such mistakes being 14 [IV. 4, 63-64].

Girls were admitted to Vedic schools or *charaṇas*. A *Kaṭhī* denoted the female student of the *Kaṭha* school. There were hostels for female students, called *Chhātrīśālā* [VI. 2, 86].

Each *Charaṇa* had an inner circle of teachers and advanced scholars, which was called *Pariṣad* whose decision on doubts about readings and meanings of Vedic texts was binding on the *Charaṇa*. The Prātiśākhya literature was the product of these *Pariṣads*.

Pāṇini gives evidence of advanced economic life. He refers to the professions or unproductive occupations called *Jānapadī Vṛtti* [IV. 1, 42] depending on pay for livelihood [*vetanādibhyo jīvati* in IV. 4, 12], as in government service. Men in service were called *Adhyakṣas* and *Yuktas* [IV. 2, 66-67]. There is mention of profession of arms [IV. 4, 14]. He also refers to labourers, *Karmakāra*, employed on wages, *Vṛtti* [I. 3, 36] under stipulated terms, *parikrayaṇa* [I. 4, 44]. Wages were paid both in cash and kind [II. 2, 22].

There is mention of trade and commerce, *Kraya-vikraya* [IV. 4, 3]. And of the necessary money-lending [IV, 4, 31]. The rate of interest is stated to be 10% whereby ten rupees lent out were to return as eleven [II.—'kusīda daśaikada-

śāt']. The debt was called after the month in which it was due for repayment [IV. 3, 47], e.g., *Āgrahayāṇika* [IV. 3, 50] or *Sāṃvatsarika* [ib.] and it could be repaid in kind, e.g., in barley [IV. 3, 48].

As regards agriculture, the plough was called *hala*, or *sīra* [IV. 3, 124]. Methods of ploughing and of sowing are indicated [V. 4, 58, 159]. Crops were called after the name of the month in which they were sown [IV. 3, 44-45] and fields after the name of the crop grown, e.g., fields of vrīhi (rice), śāli, yava, ṣaṣṭika, tila, māṣa, urṇā (linseed), bhaṅgā (hempen flex), etc. [V. 2, 2-4]. There is also a reference to *uñcha-vṛtti*, picking up grains from the fields by ascetics [IV. 4, 32].

A variety of arts and crafts mentioned. Weaving is implied in the terms *goṇī* (small sack for carrying grain), *āvāya*, and *pravāṇi* [V. 4, 160]. There is mention of cloth fresh from the loom—'tantrād acirāpahṛte' [V. 2, 70]. *Āvāya* is explained by Patañjali as the place where the weavers came and wove the cloth. Wollen cloth is mentioned (*ūrṇā*) [IV. 3, 158]. There was also *dyeing with indigo* (nīla) [IV. 1, 42] lākṣā (shellac), and yellow ointment produced from potsherds and black mud (orocanā) [IV. 2, 2]. The potter was called *Kulāla* [IV. 3, 118]. The *leatherer* was known [V. 1, 14-15]. The *fowler* was called *Śākunika* and mention is made of hunting deer and fish [IV. 4, 35].

Music was in vogue. There is mention of players on *mṛdaṅga* [IV. 4, 85], *maḍḍuka* and *jharjhara* [IV. 4, 56] and of concerts, *tūryāṅga* [II. 2, 2]; of vocalists, *gāthakas*, and dancers, *nartakas* [III, 1, 145, 146].

Crafts were organised in *guilds*, as indicated by a reference to a carpenter in the employ of the village community or working independently—grāma-kauṭābhyāṃ takṣṇaḥ' [V. 4, 95].

Excise was a source of revenue, *āyasthāna* [IV. 3, 75]. There are mentioned brewery (śuṇḍikā) [IV. 3, 76] and distillery (āsuti) [V. 2, 112].

Various *weights* and *measures* were known, such as khārī [V. 1, 33], pātra [V. 1, 40], vista (measure of length) [V. 1,

31], śatamāna [V. 1, 27] āḍhaka [V. 1, 53], āchita [IV. 1, puruṣa (man's height for measuring a ditch) [V. 2, 38], diṣṭi and vitasti [VI. 2, 31].

The following coins were known in Pāṇini's time: Kārṣāpaṇa [V. 1, 29], niṣka [V. 1, 20, 30], paṇa [V. 1, 34], pāda, māṣa [Ib.; V. 4, 1], and śāṇa (a small copper coin). There is mention of striking or stamping of coins [V. 2, 120].

The growth of group-life, popular government, and democratic institutions is evidenced in the variety of terms recorded by Pāṇini to indicate their different types. These terms may be explained as follows:

1. *Kula* and *Vaṃśa* [II. 1, 19]: *Kula* is the family which continued for generations counts as a *vaṃśa*. But the *vaṃśa* may be based on relationship in blood as well as learning (vidyā-yoni-saṃbandha).

2. *Gotra* [IV. 1, 162-165] which is a group based on relationship in blood and traced to a common ancestor after whom it is named. Thus the Vatsa gotra founded by Vatsa will count Vātsi, his son, Vātsya, his grandson, and Vātsyāyana, his great-grandson. Similarly, the term *sapiṇḍa* includes six ancestors on the male side together with their descendants up to the sixth degree. Pāṇini mentions the names of many old and famous *Gotras* such as Atri, Bhṛgu, Aṅgiras and the like, most of which became extinct. Sometimes, descendants become distinguished enough to found new Gotras, e.g., Kapi and Bodha, who were descended from Aṅgiras *gotra* [IV. 1, 107]. Some *gotras* might also derive from the mother where the father was unknown [IV. 1, 14], or from a famous member, like the Maukhari dynasty from Mukhara, in which case the *Gotra* will be called *Gotrāvayava* [IV. 1, 79].

3. *Charaṇa* [IV. 3, 104]: It was a vedic school for the study of the particular *Śākhā* or rescension of the Veda which was taught by the teacher who founds the *charaṇa* named after him. His disciples might also be the founders of new charaṇas. Thus Veda-Vyāsa had his disciple Vaiśampāyana who arranged the Yajurveda and Vaiśampāyana had disciples like Āruṇi and Kalāpin, who themselves founded new schools.

4. *Saṃgha* or Assembly, of which there were two classes, (1) *Gaṇa* and (2) *Nikāya* [III. 3, 42.86].

The *Nikāya* was a religious association in which there were no distinctions due to birth (*anantarādharaya-saṃgha*).

The *Gaṇa* was the political assembly or republic comprising all castes and a special governing caste of Kṣatriyas technically called *Rājanyas* consecrated to rulership [VI. 2, 34, and *Kāśikā's* gloss]. Only Kṣatriyas of the *Rājanya* rank could be on the governing body of the *saṃgha* or its Parliament. In the *saṃgha* government, there were also parties called *Vargas* [IV. 3, 64] named after their leader, e.g., Vāsudeva-vargya, Arjuna-vargya. There was rivalry for power, *dvanda* [VI. 2, 34] or *vyut-kramaṇaṃ* [VIII, 1, 15] between the parties, as in the Andhaka-Vṛishṇi Saṃgha. Pāṇini refers to individual *saṃghas* or republics like Kṣudraka, Mālava [IV. 2, 45], or Yaudheya [V. 3, 117] and also to confederations of republics like the Trigarta Saṃgha of six republics [V. 3, 116] or the Andhaka-Vṛṣṇi Saṃgha [V. 3, 114], of which the federal executive was made up of the *Rājanya* leader of each constituent republic with his own following or *varga*, e.g., Śini and Vāsudeva, Śvāphalka and Caitraka, or Akrūra and Vāsudeva with their rival *vargas*. The Kṣudraka and Mālava Saṃghas had also a federal army called the *Kṣaudraka-Mālavī-Senā*.

The Saṃgha as a republic naturally comprised the whole population in all its castes admitted equally to its privileges. A Brahmin and a Kṣatriya member would, however, be differently designated from a Śūdra member, e.g., a *Kṣaudraka* would denote a Brahmin or a Kṣatriya, and *Kṣaudrakya*, a Śūdra member of the Kṣudraka (Greek Oxydrakai) republic.

The expression, *chandaso nirmite*, 'passed or made by the free will of members,' indicates that the Saṃgha performed its business in accordance with the votes of its members [IV. 4, 93]. The Pāli term for vote is also *chanda*.

* The best use of the political data of Pāṇini is to be found in Mr. K. P. Jayaswal's well-known work on Hindu Polity.

Pūga or guild is sometimes [V. 3, 112] used in the sense of the village community under the Grāmaṇī. It was known for its corporate character or organisation [V. 2, 52]. Pāṇini also tells of *Kumāra-pūgas* which were like juvenile associations.

The King had his Council or Pariṣat of which the members were called *Pāriṣadyas* [IV. 4, 44]. The *Pariṣat* strengthened the position of the king who was then designated as *Pariṣadvalaḥ* [V. 2, 112]. As regards government officers, the general term was *yukta* [VI. 2, 66]. The Head of a Department was called *Adhyakṣa* [VI. 2, 67]. The officer-in-charge of rules and discipline was called *Vainayika;* in charge of Law, *Vyāvahārika;* in charge of Ways and Means, or Finance, *Oupāyika* [V. 4, 34].

বাঙ্গালার পল্লীগীতি

বাঙ্গালার পল্লীগীতি এক অপূর্ব্ব বস্তু। ইহার ভিন্ন ভিন্ন অংশে এত বিচিত্র রকমের গান, এত বৈচিত্র্যময় সুর রয়েছে যে অন্য কোনও দেশে তেমন আছে কি না সন্দেহ। এই সকল গান ও সুর সংগৃহীত হলে আমরা বুঝ্‌তে পারব যে আমাদের কত বড় সম্পদ্‌ এই সব পল্লীগীতি। পল্লীগীতি বা folk song বল্‌তে আমি সেই সকল গান বুঝি যা সরল সুস্থ পল্লীজনের সহিত অবিচ্ছেদ্য সূত্রে গ্রথিত। সেগুলি চেষ্টা করে' সাধনা করে' কলাবিদ্যার মাপকাঠি দিয়ে মেপে তৈরী হয় নি। বাঙ্গালার পল্লীগীতি তার সরল প্রাণের উচ্ছ্বসিত স্ফূর্ত্তি থেকে জন্মলাভ করেছে। আমাদের দেশের সত্যিকার পরিচয় পেতে হ'লে ঐ পল্লীগীতির মধ্যে পেতে হবে। বস্তুতঃ কোনও জাতির প্রকৃত ইতিহাস, তার নিগূঢ় মর্ম্মকথা জান্‌তে হলে শুধু তার শিলালিপি বা তাম্রশাসন সংগ্রহ করলেই চল্‌বে না। বিশেষতঃ আমাদের জাতির ইতিহাস—যারা কোনও দিন রাজনৈতিক বা সামাজিক ইতিহাস লিখবার তেমন চেষ্টা করে নি। আমাদের জাতীয় জীবনের ইতিহাস বাঙ্গালার ছড়া ও গানে, পালপার্ব্বণে উৎসবে পাওয়া যায়। এই সকল পল্লী ব্যাপারে, গান ও কবিতায় আমাদের দেশের চরিত্র অক্ষয়ভাবে মুদ্রিত হয়ে রয়েছে। সামাজিক জীবনের উচ্চস্তরে পৌঁছিয়া মানুষ যে সকল গান ও কবিতা সৃষ্টি করে, সেগুলি তার প্রবুদ্ধ চেষ্টা ও জাগ্রত সাধনার ফল। সে সব গান কবিতা দেখে' তার শিক্ষা দীক্ষার উচ্চতার পরিমাপ করা যেতে পারে, কিন্তু তার ভিতরকার জীবনের নিখুঁত পরিচয়টি লাভ করা যায় না। যেমন মনে করুন আমাদের প্রত্যেকেরই এক এক প্রস্ত পোষাকী কাপড় আছে। সেগুলি আমরা বাহিরে যাবার সময় পরিধান করি। সেই যে পোষাকী কাপড় সেটা প্রায় সকলেরই এক রকম। সেই পরিপাটী বেশবিন্যাস দেখে কারও ভিতরকার অবস্থা বুঝা যায় না। কিন্তু আমরা সেরকম কাপড় চোপড় পরে' রাত দিন থাকি না। এমন অনেকে আছেন যাঁরা ঐ পোষাকী কাপড় হয়ত ছমাসেও পরেন না। তাদের সত্যিকার পরিচয় তাদের বারমেসে ঐ আটপৌরে কাপড়ে। আরও ভাবুন, আমরা

অনেক যত্নে ও পরিশ্রমে, অনেক অর্থব্যয় ও ক্লেশ স্বীকার করে একখানি ছবি আঁকতে পারি। সেটা আমাদের উচ্চতর শিল্পপ্রতিভার পরিচয় স্বরূপে গ্রহণ করা যেতে পারে। কিন্তু আমাদের জাতীয় সৌন্দর্য্য-জ্ঞানের সন্ধান যদি কোথাও পাওয়া যায়, তবে সে ঐ আল্‌পনায়। আল্‌পনায় গৃহপ্রাঙ্গণে লক্ষ্মীর পদযুগল শত শত কুলবধূ অন্তরের সমস্ত ভক্তি-প্রীতি দিয়ে কেমন করে ফুটিয়ে তুলতো, তাই দেখে আমাদের জাতির ভিতরকার সৌন্দর্য্য-স্পৃহা সম্বন্ধে জ্ঞান লাভ করা যেতে পারে। তেমনি আমাদের কালোয়াতী গান বা উচ্চাঙ্গের কীর্ত্তন সঙ্গীত থেকে জাতীয় জীবনের যে পরিচয় লাভ করা যায়, তা ঐ পোষাকী কাপড়ের বাহারের মত। আমাদের জীবনের নিগূঢ় ঘনিষ্ঠ পরিচয় পাওয়া যায় আমাদের পল্লীগীতের নানাবিধ মীড় মূর্চ্ছনায়।

বাঙ্গালা দেশে পল্লীগীতের কি এত বৈচিত্র্যময় বিকাশ! আর কোনও দেশে এমন আছে কি না আমি জানি না। এর দুটি কারণ, একটি হচ্ছে এই যে আমাদের বঙ্গভূমি চিরদিনই ছিল খুব উর্ব্বরা। অনেক অল্প আয়াসে শস্য উৎপন্ন হতো বলে' লোকের প্রচুর অবসর ছিল, উদরে ছিল অন্ন, মনে ছিল স্ফূর্ত্তি; কাজেই তারা অবসর সময় গান গেয়ে, আমোদ করে' কাটিয়ে দিতে পারতো। উদরান্ন যতই দুর্ল্লভ হচ্ছে, ততই আমাদের আনন্দের মূল প্রপাত শুকিয়ে যাচ্ছে। আমাদের মনেও আর স্ফূর্ত্তি নাই, কণ্ঠেও সঙ্গীত নাই। আমাদের উৎসব, পূজা অর্চ্চনাগুলি আমাদের ফসলের সময়ে বেশী অনুষ্ঠিত হয়। কৃষি-কার্য্যের অবসানে যখন ধান পাকতে আরম্ভ করে, তখন আমাদের দুর্গোৎসব, লক্ষ্মী পূজা, কালী পূজা, জগদ্ধাত্রী পূজা, কার্ত্তিক পূজা ও রাস। তারপরে নবান্ন, পৌষপার্ব্বণ প্রভৃতি। এটা স্বীকার করতেই হবে যে ফসলের সময়ের সঙ্গে এদেশের আনন্দোৎসব জড়িত রয়েছে। ফসল যখন ঘরে উঠে, তখন আমাদের বসন্তোৎসব বা শ্রীপঞ্চমী; তারপরে হোলী ও চড়ক বা শিবের গাজন। এই সকল উৎসবের সঙ্গে সঙ্গে নানাবিধ নৃত্যগীতের অনুষ্ঠান হতো। পল্লীতে পল্লীতে কবির গানের দল গঠিত হতো। এ-পাড়ার দলের সঙ্গে ও-পাড়ার দলের গানের প্রতিযোগিতা হতো। কয়েক বৎসর আগেও কবিগণের এইরূপ প্রতিযোগিতা দেখেছি। হাজার হাজার লোক এই গান শুনতে জুটতো। 'কবি' এখন আর বড় শুনতে পাওয়া যায় না।

আমি পূর্ব্বে বলেছি যে, বাঙ্গালা দেশের পল্লীগানের বৈচিত্র্য দুই কারণে এত বেশী। একটি কারণ বলেছি যে আমাদের অন্ন-সমস্যা সে দিনে তেমন

জটিল হয় নি। আর একটি কারণ আমার মনে হয়, আমাদের এই বাঙ্গালা দেশে নদ-নদী বেশী। অনেক নদী খাল থাকাতে আমাদের পল্লীজীবনের সঙ্গীতপ্রিয়তা একটা বিশেষ প্রকৃতি লাভ করেছিল। এই কথাটি কলিকাতার মত মহানগরীতে বসে হৃদয়ঙ্গম করা হয়ত একটু শক্ত হবে। এখানে পথঘাট গাড়ীঘোড়ার বাহুল্যে ভারাক্রান্ত। গঙ্গাও তেমনি জাহাজ, পুল, নৌকা, গাধাবোটের দ্বারা অরণ্যে পরিণত। গঙ্গার শোভা দেখ্‌তে গেলে এই কলের কলিকাতা ছেড়ে আরও দক্ষিণে যেতে হবে। সেখানে গেলে দেখতে পাওয়া যায় কি উল্লাসে কি আনন্দে তর তর করে' কুল কুল রবে তান তুলে জাহ্নবী চলেছেন! যা দেখ্‌লে হৃদয় ভরে' ওঠে উচ্ছ্বাসে, চোখ ঢুলে আসে ঘুমে। ঐ জলকল্লোলের মধ্যে আমাদের পল্লীজীবন বর্দ্ধিত। ঐ জলের তরল স্রোতের সঙ্গে আমাদের পল্লীর সুর ভেসে ভেসে আসে। সে সুর ঐ জলতরঙ্গের মতই মিঠে। আপনারা শুনেছেন সে সুর? নিশীথ রাত্রি; অন্ধকার সমস্ত পল্লীর উপর একখানি নীল শাড়ী বিছায়ে দিয়েছে। মৃদু মন্দ বাতাসে যেন তাহা থেকে থেকে দুলে উঠছে। পল্লীবিতানে ঝিল্লীর তান আর পল্লীপথে মাঝে মাঝে কুকুরের ডাক ব্যতীত অন্য কোনও শব্দ নেই। গাঁয়ের পাশের তারা-বিদ্ধ নদীর মধ্য দিয়ে এমন সময়ে নিরালা একখানি নৌকা ঝপাৎ ঝপাৎ করে দাঁড় ফেলে' চলে' যাচ্ছে। নদীর জল স্নেহের ভরে নৌকাখানির অঙ্গ ঘিরে' চলৎ ছলৎ করে' নেচে চলেছে। তারই সঙ্গে সুর মিলিয়ে দাঁড় ফেলার ছন্দে মাঝি গান ধরেছে। চোখ যখন ঘুমে জড়িত, অঙ্গ শয্যায় এলায়িত, তখন ঐ মাঝির গানের মোহ কেমন করে শান্তিসুপ্তিমগ্ন পল্লীর প্রাণে অঞ্জলি অঞ্জলি সুধা ছিটায়ে দেয়, তা ভাষায় বর্ণনা করা অসম্ভব। সে চিত্র, সে সঙ্গীত, নীল আকাশের তারায় তারায় হীরক-চমকের মতই সুন্দর! উহারই মত সূক্ষ্ম, রহস্যপূর্ণ, গম্ভীর! মনে হয় যেন এমন মিষ্ট কিছু শুনি নি, এমন শান্তি কিছুতেই আন্‌তে পারে না। সারা প্রকৃতির সঙ্গে সুর বাঁধা কি না, তাই মানব-প্রকৃতি ঐ সুরে এত স্বাচ্ছন্দ্যের তৃপ্তি অনুভব করে। ঝিঁঝির ডাকের সঙ্গে, নদীর জলের সঙ্গে, অন্ধকারের সঙ্গে, সুর এমনই বিচিত্রভাবে জড়াইয়া এক অননুভূতপূর্ব্ব আবেশের সৃষ্টি করে যে, তাহা নিমেষে মন হরণ করে' নেয়। নদীর জলে নৌকাখানির দাগ যেমন অল্পক্ষণেই মিলিয়ে যায়, গানের সুরে আহত নিদ্রালস চৈতন্য তেমনই আবার মুহূর্ত্তে সুপ্তির কোলে ঢলে পড়ে।

এই সুরই বাঙ্গালার বৈশিষ্ট্য, ইহাই আমাদের সারিতে, বারাসে, বাউলে ফুটে উঠেছে। বস্তুতঃই এ এক অদ্ভুত জিনিষ। সারি গানে, ভাটিয়াল সুরের মধ্যে যে বৈশিষ্ট্য আছে, তার সঙ্গে পরিচয় লাভ করতে হলে বাঙ্গালা দেশের ঐ জলের চলচঞ্চল রূপ দেখতে হবে। ঐ যে জল বয়ে যাচ্চে তার আপন মনে, ছোট ছোট ঢেউ তুলে স্বচ্ছন্দ অলস গতিতে, ওর মধ্যে এমনই একটী সঙ্গীত আছে যা বাঙ্গালীর কানে সুধা ঢেলে দিয়েছে—তাকে মুগ্ধ করেছে, পাগল করেছে। ঐ জলের কল কল ছল ছল ধ্বনিতে যে আবেদন, যে অনুনয় বিনয় আছে, তাকে সঙ্গীতের মধ্যে ধরবার চেষ্টায় বাঙ্গালীর প্রাণ তৃপ্তিলাভ করেছে। বর্ষাকালে যখন বাঙ্গালার অধিকাংশ পল্লী জলনিমগ্ন হয়, নদী যখন কূল ছাপিয়ে ওঠে, তখন পল্লীবালকেরা দল বেঁধে নৌকায় 'বাছ' খেল্‌তে বাহির হয়। ক্ষেতের কাজ তখন বন্ধ, বাজার ঘাটও দুর্গম। কাজেই অবসর সময়কে সঙ্গীতের দ্বারা মুখর করে তুলবার বিচিত্র আয়োজন। যুবকের দল নৌকায় চড়ে স্রোতের সঙ্গে গান গেয়ে গেয়ে বেড়াতো। তীরে যখন শ্রোতার সমাবেশ হতো, অথবা পল্লীললনারা যখন সাঁজের বেলা ঘোমটা মুখে নাকে নোলক দুলিয়ে জল ভরতে আসতো, তখন এই গায়কেরা নৌকার উপর উঠে দাঁড়িয়ে সা'র বেঁধে গান ধরতো। এই সারবন্দী ভাবে দাঁড়িয়ে গান করার পদ্ধতি থেকে 'সারি' কথাটি এসে থাক্‌বে। সারি গানের সুরে, আমার মনে হয়, বাঙ্গালীর পল্লীজীবনের মধ্য দিয়ে জলই গান করে। মাঝি যখন ভাঁটার টানে নৌকা ছেড়ে দিয়ে সুর বিনাইয়া বিনাইয়া গান ধরে—

মন মাঝি তোর বৈঠা নেরে
আমি আর বাইতে পাল্লাম না।
আমি সারা জনম বাইলাম বৈঠা রে
এ নাও ভাটোয় সয় উজোয় না।

তখন সারা জীবনের বেদনা-রাশি চোখের কোণে অশ্রুবিন্দু হয়ে ফুটে ওঠে। ইহলোক থেকে এক মুহূর্ত্তে বিযুক্ত হয়ে অন্তরাত্মা অন্যলোকের রসাস্বাদন লাভ করে।

'বারাসে' গানেও ঐ বেদনা। ঐ বিনানো ছন্দ—ঐ জলের টানের রেখা রেখে স্বচ্ছন্দ গতিতে বয়ে যাওয়ার ভাব বর্ত্তমান রয়েছে। এতে সুর-সৃষ্টির প্রয়াস নেই; তান লয়ের প্রবুদ্ধ চেষ্টা নেই। অথচ এ আপনার কোমলতা

এমন করে' রচনা করে গিয়েছে যে পল্লীজীবন থেকে তাকে কোনও মতে বিযুক্ত করা যায় না।

আগে যদি জান্‌তাম লো ময়না
তোরে নিবে পরে
সুন্দর মতি ময়না রে
পাটার চন্দন পাটায় না থুইয়া
তোরে লইতাম কোলে লো
সুন্দর মতি ময়না।

মেয়ে স্বামীর ঘরে গেছে। নৌকায় করে' তাকে 'পরের ঘরে' নিয়ে গেছে। মা প্রতিদিন নদীর কিনারায় গিয়ে অঝোর নয়নে কাঁদে। ঐ যেদিকে তাকে নিয়ে গেছে, জলের স্রোত সেই দিকেই বয়ে যাচ্ছে। জননীর বেদনাভরা আর্ত্ত কণ্ঠের সুর তারই মত তরঙ্গ তুলে ভেসে চলেছে প্রবাসিনী কন্যার উদ্দেশে।

ঘাটে ডিঙে লাগায়ে বন্ধু
পান খা'য়ে যাও।

কোন্ অজানা বন্ধুকে প্রাণের আকুতি দিয়ে কোন্ মুগ্ধ বধূ ডাকছে কে জানে! জলতরঙ্গের সঙ্গে যে ডিঙ্গা ভেসে চলেছে, কে তার আরোহী, তা জানি নে।

কোন গেরামের লাও রে ভাই
কোন গেরামে যাও।
একখান কথা কও বা না কও
পান খা'য়ে যাও।

তার বেশী কিছু চাই নে। একবার ডিঙ্গা ভিড়াও। তোমার এই অফুরন্ত গতির কি সীমা নেই? একটু দাঁড়ালে কি ক্ষতি? একটি পান খেয়ে যথা ইচ্ছা চলে যাও, আর কিছু বল্‌ব না। বারাসের এই মোহ, জীবনে ধীরে ধীরে যেন মদিরার মত প্রবেশ করে। সুরে প্রাণ ভরে' ওঠে।

আমাদের দেশে বিবাহের দিনে মেয়েরা দল বেঁধে গলাগলি হয়ে গান গেয়ে যখন 'জল সইতে' যায়, তখন লক্ষ্য করে' দেখবেন তার সুরের ধরণ। জলের ছন্দে, ভাটীয়াল সুরে মেয়েরা তাদের উৎসব আনন্দ আশা আকাঙ্ক্ষা কেমন সুন্দর ভাবে প্রকাশ করে।

জাগরণের গান হয়ত অনেকে শোনেন নি। গ্রামে যখন কোনও উপদ্রব বা মহামারী উপস্থিত হয়, বা যখন কাহারও প্রিয়জন শঙ্কটাপন্ন পীড়ায় কাতর হয়, তখন পল্লীবৃদ্ধারা বা আত্মীয়ারা মানত করেন যে সারারাত্রি জাগরণ করে মায়ের পূজা দেওয়া হবে। সন্ধ্যার তারা দেখে জাগরণের আরম্ভ হয় এবং প্রভাতের তারা দেখে শেষ হয়। সারারাত্রি গান গেয়ে জাগরণে কাটিয়ে প্রত্যূষে গ্রামের কালীবাড়ীতে বা সিদ্ধ কোনও গাছতলায় গিয়ে প্রণাম করে' নদীতে স্নান সমাপনান্তে বাড়ী ফিরতে হয়। তারপর পূজা দিবার ব্যবস্থা। এই জাগরণের গানেও মেয়েরা বারাসে বা ভাটীয়াল সুরে গান করে। বিশেষত্ব এই যে, গানগুলি প্রায়ই দেবীর গুণ-গাথা।

ইংরেজদের মধ্যে বড় দিনে Christmas Carol গান করে' বেড়াবার রীতি আছে, বাঙ্গালা দেশেও শীতের রাত্রে পাড়ার ছেলেরা দল বেঁধে গান করে' বেড়াতো। পুরস্কার লাভ করতো অপেক্ষাকৃত অবস্থাপন্ন গৃহস্থের মেয়েদের হাতের দু'একখানা পিষ্টক। শুধু যে গরীবের ছেলেরাই গান গায়িত, তা নয়। একটু ভাল অবস্থার ছেলেরাও যোগদান করতো এবং এইরূপ গানগেয়ে যে পিঠে লাভ হতো, তাই গরীবদের বাড়ী বাড়ী গিয়ে বিলিয়ে আসতো। কাঁথা মুড়ি দিয়ে এই ছেলের পাল যখন গান গেয়ে গেয়ে দুয়ারে দুয়ারে ফিরতো, তখন পাড়ার মাঝে আনন্দের একটি সজীব উচ্ছ্বাস বয়ে যেতো।

বঙ্গের সব জেলায় যে একই রকমের সঙ্গীত প্রচলিত আছে, সবখানেই যে আনন্দপ্রকাশের ধরণ বা রীতি একরূপ, তা আমি বল্‌ছি না। আমাদের নিম্ন বঙ্গে যেখানে নদী খাল বিল অনেক, সেখানকার সঙ্গীতই আমার বিশেষ ভাবে আলোচ্য। আমি এইটুকু বল্‌তে চাই যে আমাদের দেশের প্রকৃতি সঙ্গীতের যে মধুর রূপটি সৃষ্টি করেছে, এর তুলনা অন্য দেশে খুঁজে পাওয়া যায় না। পল্লীসঙ্গীতের যে কত বিচিত্র রূপ এ দেশে আছে, তার খোঁজ অনেকে হয়ত রাখেন না। আজকাল শুধু যে এর আলোচনা নেই তা নয়, নানা কারণে লোকের মধ্যে সেই সাবেক সঙ্গীতপ্রিয়তা ও সৌন্দর্য্যপ্রিয়তার অভাব ঘটাতে এ সকল সুরও অন্তর্ধান করতে সুরু করেছে। পল্লীর যাঁরা হিতাকাঙ্ক্ষী, তাঁরা যদি একটু মনোযোগ করেন, তবে দুই একটি মূল্যবান সামগ্রী হয়ত রক্ষিত হতে পারে। মনে করুন আমাদের দেশে আগে যে কবির গান ছিল, এখন কি তা' আর আছে ? ভিন্ন গ্রামের বা একই গ্রামের বিভিন্ন পল্লীতে দল গঠিত হতো। এরা সারাদিনের পরিশ্রমের পরে কোনও

যায়গায় সমবেত হ'য়ে কেরোসিনের ল্যাম্প জেলে সারা রাত্রি 'পাল্লা' দিত। এই সকল গানের পাল্লা বা প্রতিযোগিতায় পল্লীবৃদ্ধেরা বিচারকের আসন গ্রহণ করে' জয়-পরাজয় নির্দ্দেশ করে' দিতেন। সর্ব্বশ্রেণীর হিন্দু মুসলমান এই সকল গানে যোগদান করতো। আনন্দের অবাধ মেলায় অস্পৃশ্যতা কোথায় ভেসে যেতো তার ঠিকানা নেই আইন করে' অস্পৃশ্যতা ঘুচানো যায় না। সভা সমিতিতে রেজল্যুশান করে'ও হয় কি না, সে সন্দেহ আমার আছে। ইংরেজদের মধ্যে দেখা যায় যে, খেলার মাঠে ওদের সমস্ত বৈষম্য ঘুচে যায়। আমাদের বৈষম্য, ভেদবুদ্ধি সব দূর হয়ে যেতো পল্লীর সঙ্গীতে ও উৎসবে। আমি দেখেছি যে কবির গানের শ্রোতা অনেক স্থলে হিন্দু অপেক্ষা মুসলমানই ছিল বেশী। কবির গানে হিন্দুদের পুরাণের কথাই থাকে। কবির দলের ওস্তাদ হ'তে হলে পুরাণগুলি ভাল করে' জানা থাকা দরকার। অনেক দলের ওস্তাদ মুসলমান ছিলেন; তাঁরাও পুরাণে পারদর্শী হ'লে তবে গান বাঁধবার এবং প্রতিযোগিতার ক্ষেত্রে নামবার অধিকার লাভ করতেন। এণ্টুনি ফিরিঙ্গি একজন বিখ্যাত ওস্তাদ ছিলেন। হিন্দুর পুরাণের জ্ঞান অর্জ্জন করে' তবে তাঁকে আসরে নামতে হয়েছিল। 'কবি' বা কবির গান বলা হয় এইজন্য যে, এতে 'উপস্থিত' (impromptu) কবিত্বের প্রয়োজন হতো। একদল এইরূপ গান বেঁধে একটি পুরাণ ঘটিত প্রশ্ন করলে, অপর দল তৎ-তৎক্ষণেই গান বেঁধে তার প্রত্যুত্তর দিত। কবির এই 'উতোর' অনেক সময়ে প্রতিভার বিকাশে উজ্জ্বল হয়ে উঠ্‌তো। কবির দলে ওস্তাদ ব্যতীত একজন সরকার থাক্‌তো। কোনো কোনো স্থলে ওস্তাদই সরকারের কাজ করতো। অর্থাৎ যে গান বাঁধা হলো, সেই গান সরকার কেরোসিনের ল্যাম্পের সাহায্যে পড়ে' দোহারদিগকে বলে' দিত। এমন কোথায়ও কোথায়ও দেখা গেছে যে ওস্তাদ নিরক্ষর, অথচ কবিত্বে প্রতিভাশালী বা 'উপস্থিত' রচনায় সিদ্ধ। ওস্তাদের রচনা লিপিবদ্ধ করে' সরকার গানের সময় দোহারদের পিছনে দ্রুত পাদচারণা করে' সেগুলি বলে' দিত। গান যখন শেষ হতো, তখন একজন ছড়া কেটে তার মর্ম্ম বলে' যেতো। তার নাম ছড়াদার। ছড়াদারও প্রত্যুৎপন্নমতিত্বে ওস্তাদ অপেক্ষা ন্যূন নহে। গানের দলের সফলতা অনেক সময় তার উপর নির্ভর করতো। কারণ তার কথা সকলেই বুঝ্‌তে পারে। সে যে ভাবে উত্তর দেবে, যে ভাবে গালাগালি দেবে, তাই দেখে' দলের সামর্থ্য স্থির করা হতো।

এইরূপ 'উপস্থিত' কবিত্ব ব্যতীত পুরাতন প্রসিদ্ধ পদকর্ত্তাদের রচিত পদ গান করাও হতো। সে সকল পদকে বলে বাঁধুটী অর্থাৎ অপরের বাঁধ গান। হরু ঠাকুর, ভোলা ময়রা, কাশীনাথ পাটনী প্রভৃতির নাম এই প্রসঙ্গে উল্লেখযোগ্য।

কবির গান সাধারণতঃ দুই ভাগে বিভক্ত হয়; যথা সখীসম্বাদ ও ভবানী বিষয়। কৃষ্ণলীলা বিষয়ক গানগুলিকে সখীসম্বাদ বলে। শিবদুর্গাকে অবলম্বন করে' যে সব গান, তার নাম ভবানীবিষয়।

আমি করেছি দুর্গাপূজার বোধন অধিবাস
আমার এই হৃদি বিল্বমূলে।
প্রবর্ত্তে করবো সপ্তমী,
সাধনে করবো অষ্টমী,
সিদ্ধি হলে করবো মা নবমী,
আমি বার দশরা কোরবো গিয়ে শিব রাজার সেই সুমেছলে।

জীবনান্তে শিবলোকে গিয়ে শিবের দরবারে সাধক যে মহামিলন করবেন, তারই জন্য পূজা, তারই সব আয়োজন। সরল সুরে এই গভীর ভাব পরিবেষণ করলে যে নিতান্ত নিরক্ষর লোকও তা ধরতে পারে, এ আমি নিজে প্রত্যক্ষ করেছি।

কৃষ্ণলীলা এবং শক্তির বিষয় ব্যতীত অন্য দেবদেবীর সম্বন্ধেও কবির গান রচিত হতো! কবির গানের প্রচলিত সুরগুলি আলোচনা করলে দেখতে পাওয়া যায় যে ওর মধ্যেও সেই ভাটীয়াল সুরের প্রাধান্য। কোনও জটিলতা নেই, আর্টের জন্য প্রাণান্তকর চেষ্টাও নেই। অথচ অনায়াসলব্ধ এই সুরগুলির মধ্যে এমনই একটি মাধুর্য্য ও সরলতা আছে, যাতে পল্লীর প্রাণ সহজেই সাড়া দেয়।

বাঙ্গালার অনেক স্থলে বেহুলার ভাসান বা মনসার গান প্রচলিত আছে। এরও একটি বিশেষরূপ আছে। সারি, জারি, ভাসান, কবি ও বাউলের সুরের মধ্যে এমন একটি স্বাভাবিক জ্ঞাতিত্ব আছে, যা একটু প্রণিধান করলেই ধরা পড়ে' যায়। 'ভাসান' নামটির উৎপত্তি সম্বন্ধে আমার মনে হয় যে, বেহুলা তাঁর মৃত পতিকে নিয়ে ভাস্‌তে ভাস্‌তে গিয়েছিলেন। পাড়া পড়সীরা, শ্বশুর শ্বাশুড়ী, আত্মীয় স্বজন সকলের চোখের জল উপেক্ষা করে সুন্দরী বেহুলা, অপূর্ব্ব নৃত্য-বিদ্যাকুশলা বেহুলা জীবনের আশায় জলাঞ্জলি

দিয়ে স্বামীর শব বক্ষে ধরে' অকূল পাথারে ভাস্‌লেন। তাঁর এই অনুপম ত্যাগের মহিমায় পতি জীবন ফিরে পেলেন। এই হ'লো ভাসান গানের বিষয়।

আমাদের ছেলেবেলায় আর প্রকার সঙ্গীত শুনেছি। ফকীররা যেমন মাণিকপীরের গান গেয়ে গৃহস্থের মঙ্গল, গাভীবৎসের মঙ্গল কামনা করে' পল্লীর ঘরে ঘরে ভিক্ষা করতেন, তেমনি মুসলমান গায়কেরা 'গাজির গীত' গান করতেন। গাজির গীত মাণিকপীরের গানের মত খণ্ড খণ্ড গান নয়। এক একটি সম্পূর্ণ পালা অনেকগুলি গায়কে মিলে সুর সংযোগে গান করতেন। গাজির গীতের সুর অনেকটা ঐ মাণিকপীরের গানের মত। মাঝে মাঝে পয়ারের ছন্দে বক্তৃতা থাকতো। সেগুলিও সুর করে' বলা হতো।

গাজি বলেন কালু ভাই মোর কথাটি কই।
দুই ভাই মিলে আমরা ফকীর হয়ে যাই॥

গাজিসাহেব একজন বিখ্যাত ফকীর ছিলেন। তিনি সুন্দরবনের জঙ্গলে বাস করতেন। বনের পশুরাও তাঁকে সম্মান করতো। তিনি অনেক সময় বাঘের পিঠে চড়ে' বেড়াতেন। হিন্দু মুসলমান সমানভাবে তাঁকে ভক্তি করতো। প্রবাদ আছে যে, দক্ষিণ বঙ্গের একজন হিন্দু জমিদারকে বাকী রাজস্বের জন্য নবাবের লোক ধরে নিয়ে যায়। তাঁর মা উপায়ান্তর না দেখে গাজিসাহেবের করুণা-ভিক্ষা করলেন; গাজিসাহেবও তাঁকে অভয়দান করলেন। ওদিকে নবাব রাত্রে স্বপ্নে দেখ্‌লেন যে বাঘ ভালুকে তাঁকে ঘিরেছে, আর রক্ষা নেই। শুনতে পেলেন কে যেন তাঁকে সেই হিন্দু জমিদারকে মুক্তি দিতে বলছেন। তিনি বলছেন যে মুক্তি পেলে দেশে ফিরে গিয়ে গুপ্তধন লাভ করে' সে রাজস্ব পরিশোধ করতে পারবে। নবাব প্রভাতে সে স্বপ্নের কথা ভুলে গেলেন। কিন্তু তিনি যখন দরবারে গিয়ে বসলেন, তখন দেখ্‌তে পেলেন যে উজির আমীর আমলার পরিবর্ত্তে তাঁকে বাঘ ভালুকে ঘিরেছে। তখন তিনি আর কাল বিলম্ব না করে সেই জমিদারকে ছেড়ে দিতে হুকুম দিলেন; বলে দিলেন যে, তাঁর গুপ্তধন পাবার কথা আছে সেটা পেলেই যেন বাকী রাজস্ব পাঠিয়ে দেন।

জমিদার মুক্তি পেয়ে বাড়ী এলেন। মাকে সমস্ত বৃত্তান্ত ও গুপ্তধনের কথা বললেন। তখন উভয়ে গাজিসাহেবের দর্শনে যাত্রা করলেন। জমিদার গাজিসাহেবের নির্দ্দিষ্ট স্থানে অনেক ধনরত্ন লাভ করলেন। সেই টাকা

থেকে রাজস্ব পাঠিয়ে দিয়ে হিন্দু জমিদার অবশিষ্ট অর্থে নানা স্থানে গাজি-সাহেবের দরগা প্রতিষ্ঠিত করলেন। এর থেকেই সম্ভবতঃ গাজির গীতের সূত্রপাত হ'লো।

গাজির গীত ব্যতীত আরও অনেক প্রকার গীত বাঙ্গালা দেশে সৃষ্ট হয়েছিল। সে সব ক্রমে চলে যাচ্ছে। অল্পদিন আগেও পাঁচালী শোনা যেতো। সত্যনারায়ণের বা সত্যপীরের পূজা উপলক্ষে, বিবাহের উৎসবে পাঁচালী গান দেওয়া হতো। দাশরথি রায় পাঁচালী গানের যে সুর আবিষ্কার করেছিলেন, তার একটি নিজস্ব রূপ আছে।

"বসিলেন মা হেমবরণী হেরম্বে লয়ে কোলে।"

বা "বলে গেলিনে বলে রে ভাই
আমি ভেবেছিলাম চিতে।
দিনকে বুঝি ভুলে গেছ
দিন পেয়েরে রামা মিতে।"

প্রভৃতি গানের সুর এত কোমল, এত মধুর যে তার তুলনা নেই। আজকাল পাঁচালী আর শুন্‌তে পাই নে।

পল্লীগীতির মধ্যে ঢপের নাম না করলে বক্তব্য অসম্পূর্ণ থাকবে। মধুসূদন কানের নাম এখনও লোপ পায় নি। কিন্নর বংশের নিয়মানুসারে মধুসূদনের দলে নিজ পরিবারস্থ লোক ব্যতীত অন্যের প্রবেশ নাই। শ্বাশুড়ী বধূ মিলে হয়ত মূল গায়িকা। পুত্র হারমোনিয়ম, জামাই বেহালা বাজাতেন। কন্যা ও তার জায়েরা দোহার। এমন মিলন আমাদের দেশে অন্য কোনও সঙ্গীত সম্প্রদায়ে ছিল না। কিছুদিন পূর্ব্বেও নাটোর মহারাজের বাড়ীতে তাঁদের গান শুনেছি। সে গানের এমন মতভাতি প্রায় দেখা যায় না। সুর বিস্তারে এই কিন্নর-পরিবার অদ্ভুত পারদর্শিতা লাভ করেছিলেন। আমার বোধ হয় এই ঢপ সঙ্গীত ও তার বিশেষত্বটুকু আর থাকে না। 'সেই শ্যাম নামে শুক পাখী' সম্ভবতঃ আর শুনতে পাওয়া যাবে না।

বাউল গানের সম্বন্ধে বেশী কিছু বলা নিষ্প্রয়োজন। কেননা এখনও এর প্রভাব কিছু কমে নি। রবিবাবুর খাঁটি পরিচয় বোধ হয় তাঁর বাউল গানেই বেশী পাওয়া যাবে। বাউলের গানের সম্বন্ধে এই কথাটি মনে রাখবার মত যে, বাঙ্গালা দেশে অনেক প্রতিভাশালী ব্যক্তি বাউল গানের মধ্যে দিয়ে বাঙ্গালার পল্লীতে তত্ত্বজ্ঞান ও মোক্ষের বার্ত্তা প্রচার করে' গেছেন। ইছু বিশ্বাস,

লালন ফকীর, এমন কি কাঙ্গাল হরিনাথ পর্য্যন্ত এই বাউল সুরে সহজ কথায় লোকশিক্ষা দিয়েছেন। রামপ্রসাদের সুরের বৈশিষ্ট্য সত্ত্বেও বাউলের কোঠায় তাঁকে স্থান দিতে কোনও বাধা আছে বলে মনে হয় না।

শ্রীখগেন্দ্রনাথ মিত্র

In Sir P. C. Ray we have a representative of what is best in Eastern and Western civilisation. He is a scientific chemist, at home among the most modern conceptions of the science, and by his own labours and those of his students, still continuing to advance our knowledge of the fundamental nature of chemical combination.

At the same time, by his business acumen and energy he has been able from small beginnings to build up the most successful enterprise in manufacturing chemistry in India. He may therefore claim to be able to meet the active Western world on its own ground.

Having thus won by his own efforts personal freedom and a measure of wealth, he has chosen, not the path of ostentation or display, but of simplicity and charitable service. In this he follows the best traditions of the East.

While his scientific and open mind refuses to support harmful or superstitious practices or beliefs, simply because they have the sanction of custom, he yet retains his affection for all that is wise and well-founded in the ancient religion of his forbears. Thus he retains the respect of European and Indian alike.

All who know him will unite on this occasion of his 70th anniversary in wishing him, with heartiest goodwill, every happiness in the years yet to come.

Gilbert J. Fowler.

Theories of Sex in Fungi

By S. R. Bose (Calcutta).

Sexuality of fungi in later years has attracted a good deal of attention of mycologists in various groups of fungi. It was Blakeslee (2) who first obtained experimental evidence for sexuality (heterothallism) in the Mucorales by isolating and growing single spore-cultures which by themselves produced only asexual spores, but which, when certain of them were mated together, produced *rows of zygospores* (fruit-bodies) along the line of union. On this basis he assumed that the differentiation into two strains, as plus and minus ones, was indicative of a corresponding sexual difference, and that the two strains should be regarded respectively as male and female or vice versa. This held good for the sexual condition in certain species of fungi. But in some of the Hymenomycetes it was shown by late Kniep (9) that the heterothallism was quadripolar with four genotypically different kinds of spores. Thus arose the theory of multiple sexes. As it appeared somewhat misleading to assume that there were four or possibly more than four sexes in the Hymenomycetes, it was thought that a much simpler and more workable hypothesis would be the conception of two sexes, each sex being determined by two pairs of factors and the inter-reaction of any two given haplonts being controlled by their genetical constitution. These controlling factors Kniep (9) held to be positive sex factors, and Brunswik (3) held them to be negative sterility factors. In the case of an *Agaric Coprinus micaceus* Vandendries (11) held that neither the theory of Kniep nor that of Brunswik could account for the interracial sterility of distant geographical races of the species; so he advanced the theory of sexual mutation (or mutation heterohomothallic) which is quite independent of external factors, such as

climate, latitude, habitat and other natural agents. On the other hand, Hanna (7) working with different geographical races of *Coprinus lagopus* came to opposite conclusion; he found that when monosporous mycelia from different geographiacl races were paired, complete fertility (instead of sterility) was the rule. Then, in *Ustilago zea* we have examples of saltation under cultural conditions giving rise to a large number of physiological forms; Stakman and Christensen (10) have isolated "from one line 220 mutants within a year, 162 of which were different. From another line 70 were obtained. A few lines have never been observed to mutate, others have been grown in culture for long periods of time without mutating, then they suddenly began to mutate." They hold that "variant sections or patches arise in monosporidial lines, which appear to be haploid clones, the new characters persist through a sexual propagation, and there is evidence that at least some of them persist through sexual fusions. The change, therefore, appears to be genotypic." In 1930 Gwynne-Vaughan (5) working with *Humaria granulata* tentatively put forward the theory of nutritive heterothallism not so far recorded in any other fungus. The theory can best be summarised in her own words—"Suppose that the + mycelium be a saltant possessing as an heriidtary character, the capacity of rapidly extracting from the substratum a food substance, A, essential to ascocarp formation, but is lacking, or weak, in the power to accumulate the equally necessary material B. Suppose, similarly, that a strain can obtain B, but not A. If two (+) or two (−) strains meet, the nutritive conditions for fruiting are not fulfilled, but, if − hyphae fuse with + hyphae, all requirements are met, and a row of ascocarps is the result." But Gregor (4) in her preliminary study of heterothallism in *Ceratostomella pluriannulata* has recently reported that working under the hypothesis of nutritive heterothallism of Gwynne-Vaughan—that some nutritive substance might be found whose addition to the medium would stimulate the formation of spore-bearing perithecia in monosporous cultures—she added glycerine, glucose, raffinose, pepsin, calcium phosphate, magnesium sulphate and irridiated ergosterol in the form of

"Ostelin" to + and - mycelia growing on 5% malt extract agar as a basis, but in each case she obtained only negative results. In 1931 Hartman (8) propounded the theory of relative sexuality, according to which every sexual cell is potentially bisexual and normally the dominant sex is determined by some internal factor, but if the realising factor is weak, then an external factor, such as proximity of another gamete of stronger sexual tendency, may actually determine the behaviour, so that in this case we have a typical example of relative sexuality. This is almost similar to Brunswik's (3) hypothesis of heterothallism based on one or more self-sterility factors. In June 1932 Ames (1) working with *Pleurage anserina* reported that the strains from its uninucleate spores are not heterothallic strains, male and female respectively, but are harmaphroditic self-sterile strains, requiring cross-fertilization by compatible opposites for the production of mature fruit-bodies (perithecia). He found that each monosporous culture derived from uninucleate ascospores develops both male and female organs which are self-sterile, and that by compatible crosses it can be proved that each of the male and female organs are functional. In a paper (6) published in July 1932 Gwynne-Vaughan holds that the thallus of *Ascobolus magnificus* is heterothallic but monoecious, as all thalli are capable of bearing both male and female organs which are never self-fertile but cross-fertile —a view somewhat akin to idea of "hermaphroditic self-sterile" condition.

From a survey of all these theories the idea of potential bisexuality—hermaphroditic self-sterlie strains—advanced by Ames (1) seems very striking, although it has similarities with Hartman's theory of relative sexuality and Brunswik's hypothesis of heterothallism based on one or more self-sterility factors. In the present state of knowledge, however, it would be safer not to form any decisive opinion until a larger number of species have been worked out from this standpoint of sexuality, and thereby sufficient data have been placed in our hands for the building up of a fairly stable theory.

My work with a large number of monosporous cultures (about 1,500 in number) and pairing of a number of

two monosporous cultures of *Polyporus osteriformis* Berk and *Polystictus hirsutus* Fries carried over for a period of about three years (the details of which will be published elsewhere) shows that both the species are strictly heterothallic and bisexual, in which spores from a single fruit-body fall into two groups and only two. These two sexes seemed absolutely stable as they could not be changed by variations of external conditions nor by different kinds of media. It is not improbable that the sexes of hard fungi like *Polypores*—the highest and the biggest forms among fungi regarding rigidity and solidarity—are stable and not easily interchangeable; in this respect *Polypores* would seem to resemble higher animals.

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ঋতুসংহারের দুইটি পাখী

কালিদাসসাহিত্য অবলম্বনে আমার বিহঙ্গপরিচয়ের প্রচেষ্টায় পূর্ব্বে যাহাদের সম্বন্ধে সম্যক তথ্যনির্ণয় হইতে পারে নাই, তন্মধ্যে ক্রৌঞ্চ ও কারণ্ডব বিহঙ্গ দুইটি লইয়া পক্ষিতত্ত্বের নূতন আলোকরশ্মিপাতে রহস্যোদ্‌ঘাটনের উদ্দেশ্যে এই প্রবন্ধের অবতারণা করা হইল।

ঋতুসংহারের কবি হেমন্তে ও শিশিরে ক্রৌঞ্চের সঙ্গে আমাদের পরিচয় স্থাপনের সুযোগ দিয়াছেন—

प्रभूतशालिप्रसवैश्चितानि
मृगाङ्गनायूथविभूषितानि।
मनोहरक्रौञ्चनिनादितानि
सीमान्तराण्युत्सुकयन्ति चेतः॥

শস্যবহুল প্রান্তরে ক্রৌঞ্চের মনোহর নিনাদ হেমন্তঋতুতে আমাদের চিত্তে আনন্দ সঞ্চার করে।

শিশিরে প্রভূত শালিধান্যের মধ্য হইতে ইহার কণ্ঠস্বর নির্গত হইয়া যেন শীতঋতুর আগমনবার্ত্তা প্রচার করিতেছে। তাই নবাগত শিশিরের পরিচয় দিতে গিয়া সুপক্ক শালিধান্যের মধ্যে প্রচ্ছন্ন পাখীটার কণ্ঠস্বরকে বিশেষভাবে লক্ষ্য করিয়া কবি লিখিতেছেন—

प्ररूढशाल्यंशुचयैर्मनोहरं
क्वचित्स्थितक्रौञ्चनिनादराजितम्।
प्रकामकामं प्रमदाजनप्रियं
वरोरु कालं शिशिराह्वयं शृणु॥

শ্লোকোক্ত কচিৎস্থিত শব্দ দ্বারা ক্রৌঞ্চের স্বভাবের আভাস পাওয়া যাইতেছে,—দল না বাঁধিয়া বিক্ষিপ্তভাবে বিচরণশীল বিহঙ্গটি ধান্যক্ষেত্রের মধ্য হইতে মাঝে মাঝে কণ্ঠস্বরের সাহায্যে স্বীয় অস্তিত্ব জ্ঞাপন করিতেছে।

ক্রৌঞ্চ কিন্তু যে সময়ে সময়ে ছোটখাটো দল বাঁধে, তাহার আভাসও কবি দিয়াছেন—

बहुगुणरमणीयो योषितां चित्तहारी
परिणतबहुशालिव्याकुलग्रामसीमा ।
सततमतिमनोज्ञः क्रौञ्चमालापरीतः
प्रदिशतु हिमयुक्तः काल एषः सुखं वः ॥

হেমন্তঋতুতে যখন গ্রামসীমা পরিপক্ক শালিধান্যে আচ্ছন্ন হয়, ক্রৌঞ্চ-মালাপরিবেষ্টিত সেই সীমান্তরের শোভা অতি মনোজ্ঞ। শালিধান্যের মধ্যে একাকী অবস্থিত যে ক্রৌঞ্চকে কবি কচিৎস্থিত আখ্যায় বিশেষিত করিয়াছেন, সেই বিহঙ্গই এখন নাতিবৃহৎ দলের মধ্যে সারি দিয়া অবস্থান করিতেছে,—গ্রামসীমার দৃশ্য তাই ক্রৌঞ্চমালাপরীত।

ক্রৌঞ্চের জাতিবিচারে অভিধানকারগণের মধ্যে মতভেদ দেখা যায়। শব্দার্থচিন্তামণিকার * লিখিয়াছেন—"কোঁচবক ইতি গৌড়ভাষাপ্রসিদ্ধে পক্ষিণি।" বাচস্পত্য অভিধানে লিখিত আছে "ক্রৌঞ্চঃ (কোঁচবক) বকভেদে"। ম্যাকডোনেল, মনিয়ার উইলিয়ম্‌স এবং কোলব্রুক প্রমুখ সংস্কৃতাভিজ্ঞ পণ্ডিতমণ্ডলী কিন্তু ক্রৌঞ্চের curlew বলিয়া পরিচয় দিয়াছেন। তাঁহাদের মধ্যে কেহ কেহ † ইহাকে snipeও বলিয়াছেন। পক্ষিবিজ্ঞানের দিক হইতে curlewর প্রকৃতি বিচার করিয়া দেখিলে বুঝা যায় যে, সে মুখ্যতঃ সাগরসৈকতে, নদীর উপকূলে বেলাভূমিতে থাকিতে ভালবাসে; সৈকতভূমির বালুকায় সিন্ধুতরঙ্গ প্রতিহত হইয়া যখন প্রত্যাবর্ত্তন করিতে থাকে, নিমজ্জিত বেলাতট পুনরায় যখন আত্মপ্রকাশ করে, তখন সেই আর্দ্র বালুপ্রান্তরে আহার্য্যসন্ধানে curlew ব্যস্ত থাকে। তাহার প্রকৃষ্ট বিহারভূমি হইতেছে এইরূপ বেলাতট, সাগর হইতে বালুস্তূপ দ্বারা বিচ্ছিন্ন উপহ্রদের তীর, স্রোতোবহা নদীর মোহনাসন্নিকৃষ্ট জলাভূমি; সেই জলাভূমির সান্নিধ্যে শষ্পাচ্ছাদিত প্রান্তরে কখনও কখনও তাহাকে দেখা যায়। এই বিহঙ্গ এ দেশের স্থায়ী অধিবাসী নয়, সাময়িক আগন্তুক মাত্র; শরতের প্রাক্কালে, এমন কি বর্ষা শেষ হইতে না হইতেই সে ভারতবর্ষে আসিয়া উপস্থিত হয়। এই সময় সেই বিহঙ্গচরিত্রের বৈশিষ্ট্য হইতেছে দলবদ্ধতা,—যাযাবর পাখীর ঝাঁক

* ব্রহ্মাবধূত শ্রীসুখানন্দ নাথবিনির্ম্মিত (Udaypur Sambat 1982), Vol. I, p. 711.

† Macdonell, A. A., and Keith, A. B., Vedic Index of Names and Subjects, Vol. I (1912), p. 198.

আকাশপথে রাত্রিকালে কণ্ঠধ্বনি করিতে করিতে উড়িয়া আসে। দিবাভাগে curlew যখন সাগরোপকণ্ঠে, নদীসৈকতে, ঈষৎজলাকীর্ণ প্রান্তরে দল বাঁধিয়া বিচরণ করে, তখনও তাহাদের কণ্ঠস্বরের পরিচয় পাওয়া যায়। প্রকৃতির দিগন্তপ্রসারিত বিপুল অনাবৃত দৃশ্যপটে এই বিহঙ্গ বিরাজমান থাকে; সে আত্মরক্ষায় নিপুণ বটে, কিন্তু তাহার বিহারভঙ্গী অকুণ্ঠিত, তাহার চলাফেরায় লুকোচুরি নাই। বনে জঙ্গলে, লতাগুল্মের মধ্যে, শস্যক্ষেত্রের আচ্ছাদনে সে আত্মগোপন করিয়া থাকে না। তরুবিহীন বিস্তীর্ণ বালুতটে দিগন্তচুম্বী সূর্য্যালোকে পাখীটার সর্ব্বাঙ্গ উদ্ভাসিত হয়,—প্রকৃতিপটে সে চিত্র এত প্রবল! যে আবেষ্টনে সে আহার্য্যের সন্ধান করে ইংরাজ তাহাকে "open flats" * বলেন, যে জলাভূমিতে সে বিচরণ করে তাহাকে "free-from-weeds marshes" † আখ্যায় বর্ণিত করেন।

ঋতুসংহারে ক্রৌঞ্চের যে চিত্র অঙ্কিত রহিয়াছে, তাহাতে শালিধান্যবহুল সীমান্তরের সহিত তাহার অচ্ছেদ্য সম্বন্ধ দেখা যায়। ক্রৌঞ্চনিনাদমুখরিত গ্রাম-সীমা বিশেষরূপে পরিণতশালিধান্যসমাবৃত;—মহাকবি ইহার বার বার উল্লেখ করিয়াছেন। ধান্যক্ষেত্রের মধ্য হইতে যাহার নিনাদ শুনা যায় সে হয় তো কোথাও ক্বচিৎস্থিত অবস্থায় বিদ্যমান, কোথাও বা অনুরূপ আবেষ্টনে নাতিবৃহৎ দলের মধ্যে সারি দিয়া বিরাজমান। সাগরোপান্তের বা আর্দ্র সৈকতের কোনও আভাস ক্রৌঞ্চ সম্পর্কে কাব্যমধ্যে পাওয়া যায় না। বিহঙ্গতত্ত্ববিদের নিকট curlew প্রধানতঃ সৈকতচারী "littoral species" বলিয়া পরিজ্ঞাত; ধান্য-বহুল সীমান্তরে শস্যক্ষেত্রের মধ্যে তাহার দর্শনলাভ যেমন সুকঠিন, ক্বচিৎস্থিত curlew-কণ্ঠোচ্চারিত নিনাদও শুনিতে পাওয়া তেমনি দুরূহ। প্রব্রজনশীল এই বিহঙ্গ ভারতবর্ষে আসিয়া ঝাঁকে ঝাঁকে বিচরণ করে; প্রায়ই রাত্রিকালে আকাশপথে উড্ডীয়মান অথবা নৈশভোজনতৎপর বিহঙ্গগুলার রব শ্রুত হয়। অতএব এই curlewকে কবিবর্ণিত বিশিষ্টলক্ষণাক্রান্ত ক্রৌঞ্চ বলিয়া সাব্যস্ত করা যায় না। snipeকে বিহঙ্গতত্ত্ববিৎ প্রধানতঃ নিশাচর পাখী বলিয়া গণ্য করেন। সে curlewর ন্যায় শরতের প্রাক্কালে ঝাঁকে ঝাঁকে এদেশে আসিয়া যাযাবরত্বের পরিচয় দেয়। চাহা, চ্যাগা, কাদাখোঁচা ইহার দেশীয় নাম। আর্দ্র মৃত্তিকা, জলাভূমি এবং প্লাবিত ধান্যক্ষেত্র তাহার নৈশবিহারের প্রশস্ত স্থান; দিবাভাগে সে লোকচক্ষুর অন্তরালে জলজ তৃণ ও শরবনের আচ্ছাদনে

* Dewar, Douglas, The Common Birds of India, Vol. I., Part II (1925), p. 38.

† Raoul, Small Game Shooting in Bengal (1899), p. 185.

গোপনে নিশ্চল এবং অর্দ্ধসুপ্ত অবস্থায় কালাতিপাত করে। হঠাৎ আগন্তুক মানুষ ইহার উপর আসিয়া পড়িলে সামান্য একটি ধ্বনি করিয়া পক্ষভরে ভূমি হইতে উড়িয়া পালায়। যাঁহারা ইহার বিচিত্র স্বভাবের সন্ধান রাখেন, তাঁহারা যে বিবরণ লিপিবদ্ধ করিয়া গিয়াছেন, তাহা * এই স্থলে উদ্ধৃত করা আবশ্যক মনে করি—"The chief peculiarity of the Snipe is that it is rarely seen except by those who seek its destruction. It feeds in secret, where grass and rushes grow in soft mud or shallow water." দেখা যাইতেছে যে, এই বিহঙ্গ তাহার গতিবিধি ও আহারবিহার লোকচক্ষুর অন্তরালে জলজ তৃণ, উদ্ভিদের মধ্যে গোপনে নিয়ন্ত্রিত করিয়া রাখে। শিকারী ভিন্ন অন্য কাহারও পক্ষে তাহার সন্ধানলাভ দুরূহ কার্য্য। অতএব এই নিশাচর এবং বিশেষভাবে আত্মগোপনপটু snipeকে কেমন করিয়া কবিবর্ণিত আবেষ্টনে মালা রচনা করিয়া লোকচক্ষুর সম্মুখে বিরাজমান, কোথাও বা ক্বচিৎস্থিত অবস্থায় কণ্ঠস্বরের পরিচয়ে আত্মপ্রকাশকারী ক্রৌঞ্চের সঙ্গে identify করা চলে? পূর্ব্বে সংস্কৃত অভিধানদ্বয় হইতে উদ্ধৃত করিয়া দেখাইয়াছি যে ক্রৌঞ্চ গৌড়ভাষাপ্রসিদ্ধ কোঁচবক পক্ষীকে বুঝায়। যাদবের বৈজয়ন্তী অভিধানে বকের যে সকল সংজ্ঞা বা নামভেদ দেখা যায় তন্মধ্যে ক্রৌঞ্চের স্পষ্ট উল্লেখ আছে,—

বকো বকোটঃ কহ্বোऽথ বলাকা বিসকন্ঠিকা।
বকজাতির্দ্বির্বিতুন্ডো দৰ্বিঃ ক্রৌঞ্চশ্চ দর্বিদা॥

ইহার টীকায় গাষ্টভ অপার্ট লিখিয়াছেন—kind of crane। এই crane শব্দ অবশ্যই ইংরাজি গ্রাম্য ভাষায় ব্যবহৃত,—ইহা heron পাখীকে (অর্থাৎ বক) বুঝায় †। ক্রৌঞ্চ অর্থে সুশ্রুতসংহিতার টীকায় ডল্লনাচার্য্য লিখিয়াছেন—"ক্রৌঞ্চির কোঁচবক ইতি লোকে"। বাংলার কোঁচবক সাধারণ ইংরাজের নিকট Pond-heron নামে পরিচিত। ইহার Paddy-bird আখ্যাও দেখা যায়;—ধান্যক্ষেত্রের সহিত সংশ্লিষ্ট থাকায় এই নামের সার্থকতা আছে। ইহা এদেশের এত সাধারণ, সর্ব্বজনপরিচিত পাখী,—মাঠেঘাটে, পথিপার্শ্বে, খানাডোবার মধ্যে, শস্যক্ষেত্রে আলের ধারে ভূমিতে সে প্রায়ই বিচরণ করে। ধানের ক্ষেতে সে দেহ সঙ্কুচিত করিয়া এমনভাবে বসিয়া থাকে যে সচরাচর আমাদের দৃষ্টি এড়াইয়া যায়;—কিন্তু যদি কোন কারণে সে

* EHA., The Common Birds of Bombay, Second Edition, p. 167.
† এ সম্বন্ধে বিস্তারিত আলোচনা "পাখীর কথা" গ্রন্থের মেঘদূতপ্রসঙ্গে করিয়াছি; ১৪১-১৪২ পৃষ্ঠা দ্রষ্টব্য।

আচম্বিতে ভূমি পরিত্যাগ করিয়া আকাশে উত্থিত হয়, তাহা হইলে তাহার ডানার শুভ্রতা, পক্ষসঞ্চালনভঙ্গী এবং কণ্ঠনিনাদ আমাদিগকে মুগ্ধ করে। ভেক ও কর্কটাদি ইহার প্রিয় খাদ্য; জলাশয় বা জলাভূমি হইতে এই খাদ্য সংগ্রহ করিতে হয় বলিয়া জলাভাব হইলেই ইহার স্থান পরিবর্ত্তনের প্রয়োজন হয়। বক কিন্তু যাযাবর পাখী নয়, ভারতবর্ষ ছাড়িয়া তাহাকে অন্যত্র যাইতে হয় না। ধান্যক্ষেত্রের সঙ্গে এই বিহঙ্গের সম্বন্ধের উল্লেখ বিহঙ্গতত্ত্ববিৎ জার্ডন * বিশেষরূপে করিয়াছেন,—"Its especial food is crabs, for which it watches patiently, either in the water or in the fields, and especially on the small raised bunds or divisions between rice-fields." ধানক্ষেতের মধ্যে কোঁচবক প্রায়ই বিক্ষিপ্তভাবে অবস্থান করে; তাই ক্বচিৎস্থিত বকের কণ্ঠস্বর মাঝে মাঝে শুনিতে পাওয়া যায়। কখন কোনও জলাভূমিতে বা আর্দ্র ক্ষেত্রে যদি একাধিক কোঁচবক আসিয়া উপস্থিত হয়, তাহারা কিন্তু পরস্পরের মধ্যে যথেষ্ট ব্যবধান রাখিয়া অবস্থান করে। ইংরাজ বৈজ্ঞানিক † তাহাদের বর্ণনা করিয়াছেন "like rows of miniature sentinels" অর্থাৎ ক্ষুদ্রকায় প্রহরীর সারি। কবিবর্ণিত "ক্রৌঞ্চমালাপরীত" শালিধান্যক্ষেত্রের দৃশ্য এখন বেশ হৃদয়ঙ্গম করা যায়। রাজনিঘণ্টুকার তাই বোধ হয় ক্রৌঞ্চের নামান্তর করিয়াছেন "পঙ্‌ক্তিচর"।

এখন কারণ্ডবের কথা পাড়া যাক। শরতে যে আবেষ্টনে ইহাকে আমরা দেখিতে পাইতেছি তথায় আরও কয়েকটি বিহঙ্গ বিরাজ করিতেছে

কারণ্ডবাননবিঘট্টিতবীচিমালাঃ
কাদম্বসারসকুলাকুলতীরদেশাঃ।
কুর্বন্তি হংসবিরুতৈঃ পরিতো জনস্য
প্রীতিং সরোরুহরজোরুণিতাস্তটিন্যঃ॥

কমলরেণুরাগরঞ্জিত নদী হংসকাকলিতে মুখরিত;—তাহার তীরদেশে কাদম্ব ও সারসসমূহ রহিয়াছে; কারণ্ডব তাহার বীচিমালা চঞ্চুপুটের দ্বারা বিঘট্টিত করিতেছে। একা কারণ্ডবের দৃশ্য এই প্রকৃতিপটে চিত্রিত হয় নাই,

* The Birds of India, Vol. III (1864), p. 751.

† Cunnigham, Lt.-Colonel D. D., Some Indian Friends and Acquaintances (1903), p. 166.

সেই দৃশ্যে কারণ্ডবের সঙ্গে হংস, কাদম্ব এবং সারস একত্র সন্নিবিষ্ট রহিয়াছে। এই কারণ্ডবের জাতিবিচার করিয়া দেখা আবশ্যক। দুঃখের বিষয়, সংস্কৃত অভিধানগুলি এ বিষয়ে আমাদিগকে বড় বেশী সাহায্য করে না। "কারণ্ডবকাদম্বক্রকরাখ্যাঃ পক্ষিজাতয়োঃ জ্ঞেয়াঃ" হলায়ুধে এইমাত্র পাওয়া যায়। এখানে কেবল এইটুকু বলা হইল যে, কাদম্ব ও কারণ্ডব প্রভৃতি পক্ষিজাতিবিশেষ;—কোন্ জাতি, কি বংশ, তাহা কিছুই বুঝা গেল না। অমরকোষে দেখি

নীড়োদ্ভবা গরুত্মন্তঃ পিৎসন্তো নভসংগমাঃ।
তেষাং বিশেষা হারীতো মদ্গুঃ কারণ্ডবঃ প্লবঃ ॥

যতগুলা পাখীর নাম করা হইয়াছে, কারণ্ডব তাহাদিগের অন্যতম; এখানেও তাহার বিশেষ পরিচয় পাইলাম না। তবে টীকাকার এ সম্বন্ধে যাহা বলিয়াছেন, তাহা পরে আলোচনা করিতেছি। অভিধানরত্নমালার পাশ্চাত্য টীকাকার আউফ্রেক্ট শুধু টিপ্পনী করিলেন,—'a sort of duck' অর্থাৎ হংসবিশেষ। উইল্‌সন,* মনিয়ার উইলিয়ম্‌স † ও অধ্যাপক কোলব্রুক ‡ প্রত্যেকেই নিজ নিজ পুস্তকে ঐ কথাই লিখিয়া গিয়াছেন—'a sort of duck'। অভিধানচিন্তামণিকার বলেন—"কারণ্ডবস্তুমরুলঃ"। মনিয়ার উইলিয়ম্‌স-এর অভিধানে "মরুল" শব্দ পাওয়া যায়;—ইহা এবং মরাল শব্দ সমার্থবোধক লিখিত আছে, উভয়ই হংসবিশেষকে বুঝায়। এতগুলি অভিধান দেখিয়া আমাদের স্বতঃই একটা প্রবৃত্তি জন্মে যে, কারণ্ডব হংসবিশেষ; তাহাতে সন্দেহের কারণ থাকা উচিত নহে। সুশ্রুতের টীকায় ডল্লনাচার্য্য কারণ্ডব অর্থে লিখিয়াছেন—"কারণ্ডবঃ শুক্লহংসভেদোঽল্পঃ" অর্থাৎ শুক্লহংস হইতে কারণ্ডবের কিঞ্চিৎ ভেদ বা তারতম্য আছে। এই তারতম্য বর্ণগত এবং ডল্লনাচার্য্যের মতে কারণ্ডব হংসবিশেষ বলিয়া অনুমান হয়। কিন্তু এইরূপ বর্ণনা দিয়া তিনি ক্ষান্ত হন নাই এবং আরও যাহা বিবৃত করিয়াছেন তাহাতে আমাদের পূর্ব্ব অনুমানে সন্দেহ আসিয়া পড়ে। বিবরণটি তিনি কোথা হইতে উদ্ধৃত করিয়াছেন জানি না, কিন্তু লিখিতেছেন—"অন্যেকরহরমাহুঃ। উক্তঞ্চ 'কারণ্ডবঃ কাকবক্ত্রো দীর্ঘাঙ্ঘ্রিঃ কৃষ্ণবর্ণভাক্' ইতি"। অমরকোষের টীকাকার মহেশ্বরও লিখিয়াছেন—"কারণ্ডবঃ করডুবা ইতি খ্যাতঃ। অয়ং কাকতুণ্ডো দীর্ঘপাদঃ কৃষ্ণবর্ণঃ"। দেখা

* A Dictionary in Sanskrit and English (1874).
† A Sanskrit-English Dictionary (1899), p. 274.
‡ Dictionary of the Sanskrit Language by Umura Singha (1891), p. 134.

যাইতেছে যে পাখীটা কৃষ্ণবর্ণ, দীর্ঘপাদ এবং ইহার মুখ কাকের ন্যায়। বিহঙ্গ-তত্ত্বের দিক্ হইতে বিচার করিলে দেখা যায় যে এই সমস্ত লক্ষণ হংসের হইতে পারে না। Anatidæ বংশের পাখীগুলার মধ্যে যাহারা রাজহংস এবং কাদম্ব বলিয়া পরিচিত, পক্ষিতত্ত্ববিৎ তাহাদিগকে বিশিষ্ট লক্ষণাক্রান্ত বলিয়া একটি স্বতন্ত্র অন্তর্বংশভুক্ত করিয়াছেন। আর একটি অন্তর্বংশ উল্লেখযোগ্য মনে করি, কারণ সাধারণতঃ বহু হংসই যাহা এদেশে শিকারীর চোখে পড়ে তাহারা এই Anatinæ অন্তর্বংশের পাখী। প্রথমোক্ত অর্থাৎ Anserinæ অন্তর্বংশের পাখীগুলা অধিকতর বৃহদায়তন হইলেও তাহাদের মস্তক এবং চঞ্চু অপেক্ষাকৃত ক্ষুদ্র; চঞ্চুর মূলদেশ বিশেষরূপে উচ্চ এবং চঞ্চুপ্রান্ত অতি সূক্ষ্ম হইয়া বক্রাকৃতি ধারণ করিয়াছে। Anatinæ বিহঙ্গগুলার বিশিষ্ট লক্ষণ হইতেছে—চঞ্চু প্রশস্ত এবং চ্যাপ্টা, মূলদেশের নীচে অবনমিত অংশ প্রকট। হংসের চঞ্চু কিম্বা মুখ কখনই কাকতুণ্ড বলিয়া কাহারও ভ্রম হইতে পারে না। হংসচঞ্চু হইতে ইহার পার্থক্য স্মরণ করিয়াই মনে হয় পূর্ব্বোক্ত টীকাকারগণ "কাকবক্ত্র," "কাকতুণ্ড" প্রভৃতি বাক্যের প্রয়োগ করিয়াছেন। হাঁসের পা তাহার দেহের অনুপাতে আদৌ দীর্ঘ হয় না। সমগ্র হংস বা Anatidæ বংশের বিহঙ্গগুলার চঞ্চুচরণের বৈশিষ্ট্য মিঃ ফিন * বিশদরূপে লিপিবদ্ধ করিয়াছেন; তাহা এইরূপ—*Bill* of medium length or short, usually broad, covered with skin instead of horn, except at the tip (which forms the so-called "nail") and furnished at the edges with horny ridges or "teeth"; * * *feet* with the shanks of medium length or short * *। সহজে বুঝা যাইবে যে, হংসের চঞ্চু চ্যাপ্টা ও প্রশস্ত। কাকচঞ্চুর কিন্তু গঠন অন্যরূপ,—ইংরাজ বৈজ্ঞানিক ইহাকে conical বলেন; মোচার ন্যায় বা শঙ্কুবৎ ইহার আকৃতি, সুদৃঢ় এবং ঋজুভাবে প্রলম্বিত। অতএব কাকবক্ত্র এবং দীর্ঘাঙ্ঘ্রি যে বিহঙ্গের বিশিষ্ট লক্ষণ সে হংস নহে এরূপ সিদ্ধান্ত অবশ্যম্ভাবী। কাকের মত মুখ এবং লম্বা লম্বা পা Anatidæ বংশের কোন হংসের লক্ষণ বলিয়া পক্ষিতত্ত্ববিৎ কখনই মানিয়া লইতে প্রস্তুত নন। আলোচনায় যতদূর বুঝা যাইতেছে, তাহাতে কারণ্ডবের মাত্র হংসবিশেষ বলিয়া পরিচয়ে সমস্যাটির সমাধান না হইয়া আমাদের সংশয় বাড়িয়া যায়। চরকসংহিতার টীকাকার গঙ্গাধর কবিরাজের মতে কারণ্ডব হইতেছে পানকৌড়ি। বৈদ্যকশব্দসিন্ধু গ্রন্থে† ইহার

* The World's Birds (1908), p. 30.

† বৈদ্যকশব্দসিন্ধু—কবিরাজ উমেশচন্দ্র গুপ্ত কবিরত্ন কর্ত্তৃক সঙ্কলিত (১৯১৪), ২৫৬ পৃষ্ঠা।

জলপিপি পরিচয়ও দেখা যায়। কিন্তু ডল্লনাচার্য্যের বর্ণনানুসারে পরীক্ষা করিয়া দেখিলে পানকৌড়ি এবং জলপিপি দুইটা পাখীরই মুখ কাকবক্ত্র হইতে সম্পূর্ণরূপে ভিন্ন। পানকৌড়ি যে গণ (Phalacrocorax) ভুক্ত বিহঙ্গ তাহার অবয়বগত বৈশিষ্ট্যের মধ্যে দেখা যায় যে তাহার চঞ্চু অনতিদীর্ঘ (মিঃ ফিন * "medium to short" বলিয়া ইহার পরিচয় দিয়াছেন), স্থূল না হইয়া বরং সরু এবং চাপা, অগ্রভাগ হুকের মত বক্র। জলপিপি Jacanidæ বংশের বিহঙ্গ; তাহার চঞ্চু কতকটা পারাবতের মত বটে, কিন্তু স্বাতন্ত্র্যও যথেষ্ট আছে। এই পাখীর দুইটা জাতিকে ভারতবর্ষে দেখা যায়, তন্মধ্যে একটা জাতির চঞ্চুর বৈশিষ্ট্য এই যে কপালের দিকে চঞ্চুমূল হইতে দুইটা মাংসখণ্ড প্রসারিত থাকে; কাকতুণ্ডে ইহা নাই। অতএব এই কয়েকটা বিহঙ্গের বক্ত্রের তারতম্য হইতে সহজে উপলব্ধি করিতে পারা যাইবে যে, কাকতুণ্ডের সঙ্গে হংস, পানকৌড়ি এবং জলপিপির মুখের সামঞ্জস্য নাই। এখন স্বতঃই মনে হয় যে কারণ্ডব বিহগান্তরকে বুঝায়। কি বিহঙ্গ এবং কি বিশিষ্ট পরিচয়ে তাহার স্বরূপনির্ণয় হইতে পারে ঋতুসংহার কাব্যে তৎসম্বন্ধে যথাযথ উপকরণ পাওয়া যায় না। ডল্লনাচার্য্যের নির্দ্দেশানুসারে যে আকৃতিগত লক্ষণের উপর কারণ্ডবের identification নির্ভর করে তাহা হংসে খুঁজিয়া পাওয়া যায় না; জলপিপি এবং পানকৌড়িতে কাকবক্ত্রের সন্ধান করিতে গেলে তদপেক্ষা অধিকতর হাস্যজনক আর কি হইতে পারে? রামায়ণের রামকৃত তিলকাখ্য ব্যাখ্যায় কারণ্ডবকে জলকুক্কুট বলা হইয়াছে। এই গ্রন্থের যে দৃশ্যে † কারণ্ডবকে দেখা যাইতেছে, তথায় হংসও সাধুপুষ্পিত পদ্মসমাকুল নদীমধ্যে বিরাজমান। হংস হইতে এই কারণ্ডব যে বিভিন্ন এই অনুমান স্বাভাবিক, যেহেতু হংস এবং কারণ্ডব উভয়েরই উল্লেখ আছে। ঋতুসংহারের যে দৃশ্য পূর্ব্বে পাঠকপাঠিকার সমক্ষে কাব্য হইতে উদ্ধৃত করিয়াছি সেই দৃশ্যেও হংস, কাদম্ব এবং সারসের সঙ্গে কারণ্ডবকে সন্নিবেশিত করা হইয়াছে। তাহাতে আভাস পাওয়া যাইতেছে যে এই কারণ্ডব অপর কয়েকটা বিহঙ্গ হইতে পৃথক। অতএব কারণ্ডব যে হংস নয়, এ সম্বন্ধে আমাদের পূর্ব্বের ধারণা আরও বদ্ধমূল হইয়া দাঁড়ায়। এখন তিলকব্যাখ্যায় জলকুক্কুট বলিয়া কারণ্ডবের পরিচয় যাহা পাওয়া যাইতেছে, পক্ষিবিজ্ঞানের দিক্ হইতে বিচার করিয়া দেখিলে তাহা উড়াইয়া দেওয়া চলে না। কিন্তু সে বিচারে প্রবৃত্ত হইবার পূর্ব্বে

* The World's Birds (1908), p. 13.

† রামায়ণ—কাশিনাথ শর্ম্মা কৃত দ্বিতীয় সংস্করণ (১৮২৪ শাক); অযোধ্যাকাণ্ড, ২৭ সর্গ, ১৮ শ্লোক।

একটি কথা বলা আবশ্যক। কারণ্ডব যে জলকুক্কুট এই সিদ্ধান্তের জন্য শুধু এক টীকাকারের ব্যক্তিগত মত যে দায়ী এমন নহে; বৈদ্যকশব্দসিন্ধু গ্রন্থে * লিখিত আছে—"জলকুক্কুটঃ কারণ্ডবে ; বৈদ্যকনিঘণ্টুঃ"। জলকুক্কুটের চঞ্চু এবং চরণ ভাল করিয়া নিরীক্ষণ করিলে মনে হয় ডল্লনমিশ্রের বর্ণনা তৎসম্বন্ধে বিশেষরূপে খাটে এবং দেহের বর্ণ মিলাইয়া লইলে কৃষ্ণবর্ণভাক্ পদের সার্থক্য উপলব্ধি করা যায়। এই জলকুক্কুট সাধারণ ইংরাজের নিকট coot বলিয়া পরিচিত; ইহার বৈজ্ঞানিক নাম Fulica a. atra Linn.। জলাশয়ে এবং নদীবক্ষে হাঁসের সঙ্গে একত্র তাহাকে বিচরণ করিতে দেখা যায়, এবং প্রায়ই এই অবস্থায় তাহাকে হাঁস বলিয়া ভ্রম হয়; এমন কি উৎপতন-কালেও এই ভ্রম সংশোধন হয় না। মি ডেওয়ার † বলেন—"The only bird that is likely to be mistaken for a duck when on the wing is the coot." তিনি আরও ‡ বলেন—"The coot does not appear to derive any benefit from its resemblance to the duck; on the contrary many a coot has lost its life because it has deceived inexperienced sportsmen. In this case it is similarity of habits that has brought about the likeness." অপর একজন ¶ পক্ষিতত্ত্ববিৎ লিখিয়াছেন—"Its favourite haunts are large tanks, or sheets of water, with reedy and weedy margins. Swimming about among these it looks very like a Duck and at a distance may be mistaken by anybody * * . The presence of Coots on any water is said to encourage and attract Ducks, and the two are often found in company." কিছু আশ্চর্য্যের বিষয় নয় যে এই দুইটা পাখীর একত্র অবস্থান ও স্বভাবসাম্য দেখিয়া আমাদের দেশে সাধারণ সংস্কারে উভয়কে একপর্য্যায়ভুক্ত বিহঙ্গ বলিয়া পরিচিত করা হয়। খুব সম্ভবতঃ এই কারণে সংস্কৃত অভিধানগুলিতেও তাহার ছাপ পড়িয়াছে। কিন্তু হংস এবং জলকুক্কুটগণের মধ্যে যে স্বাতন্ত্র্য আছে তাহা তাহাদিগের চঞ্চু, চরণ এবং দেহের বর্ণের প্রতি লক্ষ্য করিলে

* বৈদ্যকশব্দসিন্ধু—কবিরাজ উমেশচন্দ্র গুপ্ত কবিরত্ন কর্ত্তৃক সঙ্কলিত (১৯১৪), ৪৫৫ পৃষ্ঠা।

† Ths Common Birds of India, Vol. I, Part I (1923), p. 1.

‡ Ibid., Vol. II, Part I (1925), p. 1.

¶ EHA., The Common Birds of Bombay, Second Edition, pp. 175-176.

সহজে প্রতীয়মান হয়। মিঃ ডেওয়ার * এই স্বাতন্ত্র্য বিশেষরূপে দেখাইয়া লিখিয়াছেন—"The dark colour, the more pointed bill, the more laboured flight during which the long legs and toes project behind the tail, the fact that before he can rise from the water he has to run along the surface for a few paces, and the confiding habits should suffice to enable the tyro to differentiate the coot." এই বর্ণনা হইতে বেশ বুঝা যাইতেছে যে, জলকুক্কুটের দেহের কালো রং, ইহার অধিকতর লম্বা সূক্ষ্মাগ্র চঞ্চু এবং সুদীর্ঘ পা এবং পদাঙ্গুলি তাহার অন্যান্য বৈশিষ্ট্যের সঙ্গে তাহাকে হংস হইতে পৃথক করিয়া দেয়। হংসের ন্যায় ইহার দলে বিচরণ করা স্বভাব দেখা যায়। ভারতবর্ষের স্থানে স্থানে এই জলকুক্কুট স্থায়ী অধিবাসী বটে, কিন্তু শীতের প্রাক্কালে কোথা হইতে উড়িয়া আসিয়া এত অধিক সংখ্যায় সে এদেশের খাল, বিল, হ্রদ, সরোবর অধিকার করিয়া বসে যে সেই সমস্ত পাখীকে যাযাবর সাব্যস্ত না করিয়া থাকা চলে না। নদীবক্ষে coot-এর জ্ঞাতিবর্গকে কদাচিৎ দেখা যায়, কিন্তু জলকুক্কুট অনেকাংশে হংসভাবাপন্ন বলিয়া তথায় সে বিরলদর্শন নয়। মিঃ হুইস্‌লার † লিখিয়াছেন—"The Coot is more definitely aquatic than most of the Rail family, and frequents more open water, such as lakes, tanks and slowly moving rivers." জলকুক্কুটের কণ্ঠধ্বনি উচ্চ এবং কর্কশ; মিঃ ষ্টুয়ার্ট বেকার ‡ বলেন এই স্বর "Kraw Kraw" এইরূপ শোনায়। পাঠকপাঠিকাকে আমি স্মরণ করাইতে চাই ডল্লনাচার্য্যের কথা,—"অম্বে করহরমাহুঃ।" এই "কর হর" শব্দ উল্লিখিত "ক্র ক্র" ধ্বনির সঙ্গে মিলে না কি? বলা বাহুল্য যে পাখীর পরিচয় এবং নামকরণ অনেক স্থলে তাহার কণ্ঠধ্বনি অবলম্বনে হইয়া থাকে; দৃষ্টান্তস্বরূপ ঘুঘু, বউ-কথা-কও, টিট্টি প্রভৃতির নাম করা যাইতে পারে।

শ্রীসত্যচরণ লাহা

* The Common Birds of India, Vol. I, Part I (1923), p. 1.

† Popular Handbook of Indian Birds (1928), p. 339.

‡ Journal of the Bombay Natural History Society, Vol. XXXI (1926), p. 546.

ব্যবসায় ক্ষেত্রে বাঙ্গালীর স্থান

ব্যবসায় ক্ষেত্রে বর্ত্তমানে বাঙ্গালীর স্থান কোথায় ইহা আর বিতর্কের বিষয় নাই। অন্যান্য ব্যক্তিদের তুলনায় বাঙ্গালী যে এ ক্ষেত্রে অনেক পশ্চাতে আসিয়া পড়িয়াছে এবং নিত্যই অতি দ্রুতবেগে পিছাইয়া যাইতেছে ইহা এক্ষণে সর্ব্ববাদিসম্মত। ব্যবসায়ের উদ্দেশ্য অর্থোপার্জ্জন। বাঙ্গালীর যে অর্থে আসক্তি নাই একথা বলা না যাইলেও, ব্যবসায়ই লক্ষ্মী-লাভের প্রথম উপায় ইহা বঙ্গবাসীর কাছে অবিদিত না থাকিলেও, বাঙ্গালী দিনের দিন ব্যবসায়ের পথ হইতে সরিয়া আসিতেছে। আসিতে বাধ্য হইতেছে ইহাও বলিতে পারা যায়। তাহার অর্থে আসক্তি থাকিলেও উপার্জ্জনে আসক্তি নাই। ইহার প্রতিকারের প্রয়োজনীয়তা কি আজিও এই দারুণ অন্নসমস্যার দিনে উপলব্ধি হইতেছে না? যদি হইয়া থাকে তবে উপায় কি?

উপায়ের কথা চিন্তা করিতে হইলে প্রথমেই মনে করা আবশ্যক যে, তীক্ষ্ণবুদ্ধিশালী বাঙ্গালী বিদ্যাবুদ্ধিতে ভারতের সকল শ্রেষ্ঠ ব্যক্তির অন্যতম বলিয়া পরিগণিত। মনীষিপ্রবর লালা লাজপত রায় যে বাঙ্গালাকে রাজনীতিক্ষেত্রে ভারতের অন্য সকল প্রদেশের অগ্রণী বলিয়া অভিহিত করিয়া গিয়াছেন সেই বাঙ্গালার অধিবাসী বাঙ্গালী ব্যবসায়ে এত পশ্চাৎপদ কেন? পাশ্চাত্য জাতিগণ বণিকের বেশে এদেশে যখন প্রথম আগমন করেন, তখন কৃষি, শিল্প ও বাণিজ্যে বাঙ্গলা অতীব সমৃদ্ধ ছিল। তখন সর্ব্বাগ্রে তাঁহাদের এ দেশীয় ব্যবসায়ী বণিক ও শিল্পীদের সংস্পর্শেই আসিতে হইয়াছিল, সামান্য শিল্পী ও ব্যবসায়ীদের দ্বারস্থ হইয়াই তাঁহারা শনৈঃ শনৈঃ তাঁহাদের স্থান করিয়া লইয়াছেন। তখনও বাঙ্গালা সত্যই ধনধান্যেপুষ্পেভরা সোনার বাংলা ছিল। মহাপ্রতাপশালী মোগল সম্রাট-গণের মধ্যেও কেহ কেহ এই বাঙ্গালাকে সাম্রাজ্যের মধ্যে অতি উচ্চ স্থান দিয়া গিয়াছেন। আর তারপর আজ দুই শতাব্দী অতিবাহিত না হইতেই

এ কি পরিবর্ত্তন! যে বাঙ্গালার পণ্য দেশবিদেশের আদরের বস্তু ছিল, যে বাঙ্গালার সূক্ষ্ম বস্ত্র সমগ্র জগতের বিস্ময়ের সামগ্রী ছিল, সেই বাঙ্গালার সন্তানদের আজ পরণের বস্ত্র নাই, আহারের অন্ন নাই। বাঙ্গালী আজিও বর্ণ-বিভাগ লইয়া বিব্রত, তাহাদের কর্ম্মবিভাগ আর বড় দেখা যায় না। বাঙ্গালার কামার, কুমোর, তন্তুবায়, কংসবণিক প্রভৃতি ক্রমেই তাহাদের স্ব স্ব বৃত্তি ভুলিতে চলিয়াছে; তাহাদের সে শব্দমুখরিত কর্ম্মশালা এখন নিস্তব্ধপ্রায়। বাঙ্গালীর দেশান্তরে যাইয়া বাণিজ্যের কথা ছাড়িয়া দি, বড় বড় ব্যবসায়-সকল অনেকদিন হইতেই প্রায় তাহাদের হস্তান্তরিত হইয়াছে; এখন সামান্য কাজগুলিও ক্রমে অতি দ্রুতভাবে তাহাদের আয়ত্বের বাহিরে চলিয়া যাইতেছে।

ভারতের দ্বিতীয় নগরী সর্ব্বপ্রধান বাণিজ্যকেন্দ্র কলিকাতার হাটখোলা, লোহাপটি, বেলেঘাটা প্রভৃতি প্রধান প্রধান বাজার বা ব্যবসায়ক্ষেত্রগুলি যাহা পঁচিশ ত্রিশ বৎসর পূর্ব্বেও বাঙ্গালীর একচেটীয়া ছিল, আজ সে সকল বাজারের আধিপত্য অবাঙ্গালীর হস্তে চলিয়া গিয়াছে। যাহারা তখন তাহাদের ব্যাপারি ছিল, যাহাদের অনুগ্রহের উপর নির্ভর করিয়া তাহাদের আপন আপন মোকামে মালপত্র সরবরাহ করিতে হইত, আজ বহুক্ষেত্রে তাহারাই মহাজন। বাস্তবিক ব্যবসায় ক্ষেত্রে তাহাদের দ্বারেই আজ বাঙ্গালীকে প্রার্থী বা প্রত্যাশীরূপে দেখা যাইতেছে। ছোট ছোট ব্যবসায়ীদের এমন কি মেরিওয়ালাদের স্থানও বহুল পরিমাণে ভিন্ন দেশীয়দের দ্বারা ক্রমশঃই অধিকৃত হইয়া যাইতেছে। আর আশ্চর্য্যের বিষয় এই যে, এজন্য ঠিক যাহাদের বেশী চিন্তা হওয়া উচিত, যাহাদের মুখের গ্রাস চলিয়া যাইতেছে, তাহারা অন্নের জন্য লালায়িত হইলেও এদিকে একেবারে দৃষ্টি নাই। যত চিন্তা যত মাথাব্যথা দেখা যায় একটীমাত্র সম্প্রদায়ের, যে সম্প্রদায়ের সম্পদ কালিকলম, কার্য্য লেখনীসঞ্চালন দ্বারা উপদেশ দেওয়া। তাঁহারা অন্য কেহ নহেন, বাঙ্গালার লেখকসম্প্রদায়।

বাঙ্গালী অর্থ চায়, সম্পদ চায়, ব্যবসায় বাণিজ্যই অর্থাগমের প্রকৃষ্ট পথ ইহা জানে এবং পরদাসত্বের দ্বারা অর্থসম্পদে সম্পদশালী হওয়া যায় না ইহা বিশেষরূপেই অবগত আছে, তথাপি ব্যবসায় ক্ষেত্রে এত পশ্চাৎপদ, তথা হইতে দূরে থাকিতে চায় কেন? ব্যবসায়ে বাঙ্গালীর এ বিমুখতা কোথা হইতে আসিল? বাঙ্গালীর এদিকে অবনতির কারণ অনুসন্ধানে

প্রবৃত্ত হইলে দেখা যায়, বাঙ্গালী ব্যবসায় করিতে চায় না, ব্যবসায়ের বিষয় শিক্ষা করে না। পূর্ত্ত, রসায়নবিদ্যা, কমার্শ প্রভৃতি বিষয় যাঁহারা শিক্ষা করেন তাঁহাদের উদ্দেশ্য ব্যবসায় করা নহে, অন্যরূপ। বাঙ্গালীর এহেন মনোবৃত্তির মূলে দেখা যায় তাহাদের পরিশ্রমবিমুখতা ও বিলাসিতা। বাঙ্গালী এমন আয়েসপ্রিয় ছিল না; এমন বাবু, এমন বিলাসে মগ্ন কোন দিন ছিল এ প্রমাণ পাওয়া যায় না। কোথা হইতে কি সূত্রে তাহাদের স্বভাবের মধ্যে এ পরিবর্ত্তন ঘটিল তাহার গবেষণায় প্রবৃত্ত হইলে বুঝা যায়, তাহাদের এ পরিবর্ত্তনের সূত্রপাত হইয়াছে সেই দিন যে দিন শিল্পব্যবসায়াদি দ্বারা আয়াসলব্ধ অর্থের পরিবর্ত্তে অন্নসংস্থানের জন্য কেরাণী-জীবনের নূতন পথ তাহারা দেখিতে পাইল। উহা বৈদেশিক শাসনের প্রথম যুগ। উহাকে বাঙ্গালীর জাতীয় জীবনের একটা যুগসন্ধিকাল বলা যাইতে পারে।

সে সময় শাসকসম্প্রদায় চাহিয়াছিলেন তাঁহাদের রাজস্ব পরিচালনার সহায়তা ও প্রজাদের রাজভক্ত করিবার জন্য একদল ইংরাজীশিক্ষিত বাঙ্গালী। তাঁহাদের নবলব্ধ রাজ্যরক্ষা ও বিস্তারের সহায়তার জন্য এক সম্প্রদায় ভারতবাসী। তাঁহাদের স্বদেশীয় পণ্য ভারতের বাজারে চালাইয়া বিলাতি বাণিজ্যের প্রসারবৃদ্ধির জন্য ভারতীয়দের মধ্যে ইংরাজী হাবভাবের প্রবর্ত্তন। দীর্ঘ পরাধীনতার পর নূতনের মোহে পড়িয়া বাঙ্গালী সে সময় রাজ ইচ্ছায় সানন্দেই সাড়া দিয়াছিল। তাহারা তখন সামান্য পরিশ্রমে মোটা মোটা চাকুরীর লোভে অর্থোপার্জ্জনের প্রকৃষ্ট পথ ছাড়িয়া রাজভাষা শিক্ষায় মনোযোগী হইয়াছিল। পরন্তু একদিকে রাজবিধিজনিত দেশীয় ব্যবসায়বাণিজ্যের বহু বাধা ও শিল্পসাধনার অন্তরায়, অন্য দিকে তীক্ষ্ণবুদ্ধি উর্ব্বর মস্তিষ্ক বাঙ্গালীর কেরাণীগিরিতে উৎকর্ষতা লাভদ্বারা আত্মপ্রসাদ অনুভব,—এই দ্বিবিধ কারণ সে সময় বাঙ্গালীকে অধিকতর ইংরাজী শিক্ষায় উদ্বুদ্ধ করিয়াছিল। শাসকসম্প্রদায়ের এই শিক্ষাদান ও বাঙ্গালীর মস্তক পাতিয়া তাহা গ্রহণ—ইহাই বাঙ্গালীর জাতীয় জীবনের পতনের মূল কারণ।

এই শিক্ষার জন্য তখন মিশনারীদের চেষ্টাও যথেষ্ট ছিল। তাহাদের উদ্দেশ্যের মধ্যেও এমন কিছু ছিল না, যাহাতে আমাদের জাতিগত উৎকর্ষ সাধিত হইতে পারে। তাঁহারা চাহিয়াছিলেন এই শিক্ষার সহায়তায় এদেশে

খৃষ্টধর্ম্মের প্রচার। তাঁহারা যাহা চাহিয়াছিলেন তাহাও সে সময় অনেকাংশে সফল হইয়াছিল। সুতরাং বেশ দেখা যাইতেছে যিনি যাহা চাহিয়াছিলেন তিনি তাহাই পাইয়াছিলেন এবং প্রকারান্তরে তাঁহাদের দ্বারা উদ্বুদ্ধ হইলেও বাঙ্গালী অনায়াসে অন্নসংস্থান করিবার যে উপায় খুঁজিতেছিল তাহাতে তাঁহারা আরও অধিকতর কৃতকার্য্য হইয়াছিলেন। তাহাতে তখন জাতীয় অর্থসমস্যা সমাধানের পথরোধ হইলেও ব্যক্তিগতভাবে কতক লোকের অন্ন-সংস্থানের পথ সুগম হইয়াছিল একথা স্বীকার করিতে হইবে। কিন্তু আজ আর সেদিন নাই, অবস্থা অন্যরূপ হইয়াছে, আজ বাঙ্গালী অন্নবস্ত্রের কাঙ্গাল। তাহার দৃষ্টিতে সকল পথ রুদ্ধ, সকল দিক তমসাবৃত। তাহার জাতীয় অসচ্ছলতার কথা চিন্তা করা দূরে থাক, নিজের ও পরিবারবর্গের গ্রাসাচ্ছাদন—দিনগত অভাব পূরণেও আজ সে অসমর্থ। দেড় শতাব্দীর অভিজ্ঞতায় এখন অনেকেই বুঝিয়াছেন, যে শিক্ষা ও শিক্ষাপদ্ধতি দেশে প্রচলিত আছে তাহাতে বাঙ্গালীকে জ্ঞানগরিমা ও সম্মানে অপরের তুলনায় সমৃদ্ধ করিতে সমর্থ হইলেও তাহা তাহাদের জাতীয় ধনসমৃদ্ধি বৃদ্ধির পক্ষে আদৌ সহায়ক নহে; তাহার দ্বারা দেশের অর্থসমস্যা সমাধানের প্রকৃষ্ট পথ প্রাপ্ত হওয়া যায় না, যুবকদের ধনলিপ্সা জাগরূক করিবার পক্ষে মোটেই তাহা উপযোগী নহে। সুতরাং অর্থনৈতিক দিক হইতে বিবেচনা করিলে বলিতে হয়, এ শিক্ষা সেদিকে সফলতা আনিতে পারে নাই। মাড়োয়ারি, ভাটিয়া, কেঁইয়া প্রভৃতি জাতি যাহারা ইংরাজী শিক্ষায় এখনও অপেক্ষাকৃত হীন তাহাদের, এমন কি বাঙ্গালার মধ্যেও অপেক্ষাকৃত অল্পশিক্ষিত জাতিদের ব্রাহ্মণাদি উচ্চ-বর্ণের তুলনায় স্বাধীন ব্যবসায়ে কৃতিত্বের কথা চিন্তা করিলে ইহার যাথার্থ্য উপলব্ধি করিতে পারা যায়। এক্ষণে ইহাও সকলেই বুঝিয়াছেন দাসত্বের দ্বারা কখন কোন জাতি বড় হইতে পারে না। ইংরাজী শিক্ষার দ্বারা জ্ঞানবিজ্ঞানে আমরা যথার্থ উন্নত হইলেও বর্ত্তমান শিক্ষা আমাদের জাতীয় জীবনের প্রসার ও কল্যাণের সহায়ক নহে, বরং পরিপন্থী।

ব্যবসায় ক্ষেত্রে বাঙ্গালীর অধঃপতনের কারণ তাহাদের মনোবৃত্তি, তাহাদের বিলাসিতা, পরিশ্রমবিমুখতা ও পরমুখাপেক্ষিতা এবং তাহাদের আধুনিক শিক্ষা। স্ব-বৃত্তি হইতে তাহারা অপসারিত হওয়াতেই আজ তাহাদের এই দারুণ সমস্যার সৃষ্টি হইয়াছে। যে সকল মহাত্মা বর্ত্তমানে বাঙ্গালীর এই প্রধান সমস্যা সমাধানের জন্য চেষ্টিত তাঁহারই জাতির প্রকৃত বন্ধু।

দেশের এই দুর্দ্দিনে যাহাতে বাঙ্গালী যুবকগণ আত্মপ্রতিষ্ঠ হইয়া জীবন যাপন করিতে সমর্থ হয় সেজন্য যে সকল মনীষী আত্মনিয়োগ করিয়াছেন, তন্মধ্যে মহাত্মা প্রফুল্লচন্দ্র প্রধান বলিলে অত্যুক্তি হয় না। সচরাচর বাঙ্গালী যে বয়সে কর্ম্মক্ষেত্র হইতে অবসর লইয়া শান্তিলাভার্থ বিশ্রাম গ্রহণ করিয়া থাকেন, প্রফুল্লচন্দ্র সেই বয়সে সর্ব্বত্যাগ করিয়া দেশের বেকার সমস্যা সমাধান দ্বারা জাতীয় কল্যাণের জন্য জীবনপণ করিয়াছেন। পরার্থে এত বড় ত্যাগের দৃষ্টান্ত বিরল। আমার এ ক্ষুদ্র প্রবন্ধে নূতন কথা কিছুই নাই, আজ সেই ত্যাগী মহাপুরুষের জন্মোৎসবে শুধু তাঁহারই কর্ম্মপ্রচেষ্টার কথা স্মরণ করাইয়া দিবার জন্য কিছু আলোচনা করিলাম মাত্র।

শ্রীহরিহর শেঠ

The Soul of India

By Nares Chandra Sengupta (Calcutta).

The soul of India has formed the theme of many a learned discourse. Men have gone burrowing into the past to discover it and we have had no end of men who have come forward each with his own favourite miniature of the article which he has sought to pass off as the real thing.

I have ever felt such efforts to be futile and the more I have dived into the learning of India's past the less I cared for any school of thought which caught hold of a single strand of the mind of India in the past and looked upon that as the whole fabric of soul of India even of the past.

The soul of India is not to be read in the solemn abstract thoughts of the Upanishads alone, nor in the colourful and varied pictures of the Puranas alone, but in all the entire rich and varied life of the past with its sciences and arts, with its folklore and music and with its flights of fancy in literature and art. It is not one simple thing but a great web of the varied yarn that went to make the life of the past.

And, if there is one thing which shows more than any other the real life and soul of the past it is not the lofty thoughts of the elite embodied in the Upanishads, but the life and mind of the people as shown from their laws and institutions embodied in the Smritis. These show, unlike the sublime literature, that those ancient people were not mere philosophical dreamers but very practical men who cared a great deal for the good things of the earth, worked and fought for them and employed all the resources of their mind to multiply them. In fact, reading the Smritis through, in the light of other ancient systems of law one cannot but feel that the ancient Hindus were anything but the dreamers

that they are painted to be. They were an eminently practical race who had their senses wide awake to the realities of the universe and were ever ready to take advantage of them for the improvement of their earthly lot.

The course of the growth of the Smriti literature in same measure indicates how the decadence set in which diverted the mind of the Hindu race to thoughts of the other world to the utter neglect of this. The earlier Smritis throughout indicate a healthy and vigorous development of all sides of life which is reflected in the corresponding developments in the chapters dealing with positive law. The Smritis of Narada, Katyayana, Yama, Vrihaspati and others, judging from the excerpts from these works still retained to us indicate the high watermark of social development. Kautilya's Arthasastra and Vatsyayana's Kamasutra are in the main also indicative of that healthy growth of society on all sides.

At the same time these later Smritis show how the seeds of decay were setting in. The growing preponderance of the sacral element in these later Smritis and the tightening grip of sacrament in them show how the sacerdotal element was extending its stranglehold on the life of society.

In the early Smritis we find that society and law are sensitive to changes in environment and they do not hesitate to appropriate or adapt things and institutions which they find around them. The whole body of Dharma Sutras are full of instances of such growth by adjustment to environments. But I shall illustrate what I mean by a brief reference to the evolution of marital laws.

Marital laws are the pivot round which society and social institutions grow, and in a very large measure they determine the structure and functions of society. In the earliest records of Vedic culture in the Rg Veda, the Atharva Veda and the Grihya Surtras we find that the only form of marriage known to and recognised by the ancients was one solemnised by appropriate sacrifices in the house of the bride's father followed by a journey to the bridegroom's house, which bear obvious analogies to the marriage laws of Athenians and early Romans. There could be no other valid marriage. As you come down to the Dharma Sutras you

find that other forms are slowly finding admission into orthodoxy, as much as co-emptis and usus came to be recognised in Rome—until you come to the list of eight kinds of marriage in the latest Dharma Sutras and in the Smritis.

What does this indicate? It clearly implies that these new forms of marriage, such as marriage by capture, by purchase etc., had actually been so widely practised in society that law had to recognise them in the long run. And what was the reason that these practices grew up amongst the people? The reason is that in the new environments in which society found itself the strait lace of ancient law proved too narrow to satisfy the demands of society. Society therefore adapted itself to its new environments and appropriated the froms of marriage that it found in vogue among the peoples among whom they had settled.

A striking indication of where these new forms of marriage were obtained from is to be found in the name of one of these forms—the Assura, which is the name given to the system of marriage by purchase. That was precisely the form of marriage in vogue among the Assurs—as evidenced by the code of Hammurabi and numerous other documents. It is reasonably clear therefore that this form of marriage was adopted by ancient Indians from the Assurs. So too the other forms of marriage must have come into vogue by adopting the customs of other races among whom the Aryans found themselves.

This is a theme far too large to enlarge on within the brief compass of this essay. But my studies have convinced me that this was the fact. When ancient Indian society felt a social necessity which its laws did not satisfy, it did not scruple to borrow from its neighbours all that was needed to satisfy the cravings of society and give free play to its life. It was the same everywhere. And the whole history of ancient Indian culture is not a history of mere natural or logical evolution of some primordial seed, but growth by absorption and assimilation from life-giving thoughts and ideas which the people found around them.

That was the story in days when society was still vigorous and alive. Those were days in which society responded sensitively to

the environment and absorbed ideas and institutions, goods and merchandise, as well as whole races of men and assimilated them with itself. Law had to follow in the wake of the triumphal march of bubbling life. It was not yet a cage which closed round the society and cramped and devitalised it.

But the custodians of sacred law were never any but grudging parties to all this social expansion. If they recognised new growth it was because they had to. And at every step they took, they tried to set bounds to further growth by placing the new institution itself within the bounds of sacred law. Here again marriage laws afford an instructive example. When Vasistha extends his recognition to these new forms of marriage, he seeks to limit them by saying that they must none the less be sanctified by the Grihya ritual of marriage. These early attempts to set bounds to these novel institutions failed. Once in a time we do find a marriage by capture, as for instance that of Ambika and Ambalika sanctified by a subsequent ceremony. But the Mahabharata is full of stories of marriage by capture and gandharva marriages which were never followed by a ritual.

If we follow the fortunes of marriage laws in subsequent literature, we find that the ritual marriage came in course of time to be confined to Brahmans alone, while Kshastriyas, Vaisyas and Sudras used to marry in other ways, and we find Manu setting the seal of his approbation on this law. But in later times the seed sown by Vasistha germinated. There came a time when the sacerdotal element in society had gained complete ascendancy, and, at this stage, in various nibandhas we find it authoritatively laid down that no form of marriage was valid which had not been accompanied by the Grihya ritual.

The sacred law had at this stage asserted its hold on the life of the people. Room for natural expansion of society by free adaptation to environment was gone. Every day and hour of life, every little thing that men could do was now regulated by an unalterable sacred law. Society had lost its power to expand, it shrank into its narrow shell, out of touch with the world outside.

A study of the entire Smriti literature indicates how the change came about. As I have said before, the Dharma Sutras and Smritis show a steady and vigorous growth of the life of society although, already in the later Smritis, the fetters of sacred law were being multiplied. The early nibandhas and commentaries, written by practical lawyers and statesmen while they disclose without mistake the complete hold of sacerdotal law, are yet not mere manuals of sacrament, but devote a large part of them to positive law. But as you come to the later nibandhas you find the sacral law growing more and more and positive law shrinking. The culmination of this development is marked in works like Hemadri and the Smriti of Raghunandana whose twenty eight chapters have no room for any positive law except that relating to the law of inheritance, while Ekadasi, Malamash and such other weighty sacral topics fill whole chapters of the work.

Raghunandana wrote in a society in which Hindus had lost all political power. Public laws were matters of no concern to them. Orthodox Hindu socitey had no concern with politics or the administration of laws except in matters like marriage and inheritance. Hindu mind so far as it responded to this new environment did so by accepting and bowing to the laws of their rulers. But the bulk of Hindu society which had lost its elasticity and adaptability turned its mind away from topics like these and got itself entirely absorbed in exploiting the ritual and metaphysical wealth of their ancestors, absolutely out of touch with the times.

That is how decadence set in and was perpetuated. The rigours of law closed upon a devitalised society and made it incapable of responding to the changes in environment. And, as political authority passed out of the hands of the Hindus and the practical world was dominated by the Moslem conquerors, Hindus as such, shrunk in stature beyond recognition, found their sole comfort in rummaging their old treasures in the domains of religion, philosophy and ritual. It was in the age of this decadence that Hindu India, let alone in its position of isolation from the main stream of life, developed an exclusively spiritual, religious

and ritualistic outlook which most people have taken to be the spirit and essence of the soul of India, ancient and modern.

A study of the laws and institutions of the past, of the literature, science and art, of its industries, trade and commerce and of the evidences of the entire life of ancient Indians in days when they were a live race give the lie to such a conception of the soul of India. It was never the cramped and narrow thing, exclusively spiritual, with no interest in anything but the supramundane that it is supposed to be. Spiritual it was and religious like every other ancient society, but the religion and spirituality of ancient Indians ran like a golden string through its variegated life and while they inspired and expanded its action and thought they did not have the terrifying and cramping influence which could blind the people to the good things of the world.

That was the real soul of India of the past, alive and wide awake, with interests as wide as the bounds of human mind, never failing to adapt itself to whatever environment it found itself in.

That soul of India is not dead.

After a long age of hibernation under the freezing influence of sacerdotalism she has been born anew, with life flowing in every limb, and ready for any enterprise. She is no longer afraid to face the open air and light of whole world, she will not shrink from the fight with the torrents that may beat on her from the world outside. She has opened her doors wide to the world of thought and is as keen as she was in the remote past to glean sustenance from all quarters of the new world she finds herself in.

That is the soul of India reborn, revitalised. Her sleep was broken by the magic wand of Raja Ram Mohan more than a century ago. Since then she has lived and grown and thriven on the labours of scores and hundreds of the children of light in the front ranks of whom the name of Acharyya Prafulla Chandra will always have an honoured place. For it was he who opened the door to a new font of light for the children of India in the worthy company of his great contemporary Sir Jagadis Chandra Bose. And in more ways than one he represents the soul of India of to-day.

Dr. Sir P. C. Ray — The real man

By **Rai Bahadur Hiralal** (Katni).

Somebody has pointed out that it is the trifling acts of a person which exhibit his real character, and I fully realized the truth of this assertion in the case of Sir P. C. Ray, whom I had the good fortune to meet though only casually on three occasions, the first two of which were quite accidental. But every time I found something in his behaviour, which spoke volumes of his goodness and purity of heart. On the first occasion he unwittingly demonstrated *udara charitanantu vasudhaiva kutumbakam*, on the second his simplicity of living, and on the third his mature experience and profound love of his pupils. Indeed on every occasion his love for his pupils was a predominating feature.

It was in the year 1921 that I happened to come in contact with him for the first time, quite accidentally. I went to Calcutta for attending the 8th session of the Indian Science Congress, whose Reception Committee was headed by the late Sir Asutosh Mookerjee as President and Dr. Suhrawardy as Secretary. On arrival the delegates from the Bombay side, including myself, were somewhat surprised to find nobody present at the railway station to guide us to the lodgings fixed for us at the Science College, of which we had been previously informed. As nobody on the spot could tell us where this College was situated, we drove straight to the University Buildings, where we got the necessary information to reach the destination. On entering this building we encountered a gentleman, whom we requested to tell us the rooms we were expected to occupy. This gentleman was no other than Dr. P. C. Ray and he questioned us whether we had not been informed of the changes subsequently made shifting the lodgings to the Law College Buildings. On receiving a reply in the negative he re-

marked, "This is the business of big men and hence all this confusion. That is why I did not go to big men who invited me to stay with them at Bombay when I returned from England. I went to my pupils and was very comfortably lodged with them." Meantime one of his pupils, the head of an important institution in Calcutta, arrived and asked for my name, which he at once associated with Nagpur, where, he said, he had no such wandering about as we had had, when he visited that place the previous year for the same purpose for which we came to Calcutta. He spoke of the reception arrangements at the Nagpur railway station very approvingly and felt a bit hurt at the idea of our possibly carrying away an unfavourable impression of the Calcutta arrangements. Dr. Ray at once gave us a peon to take us to the Law College Buildings, but his pupil would not be satisfied with that. He took us into his motor car and conducted us personally to that place. We were mere strangers, but the anxiety of the saint-like Acharyya of Calcutta to put us in comfort made a deep impression on our minds. The incident exhibited also the great regard he had for his pupils, who reciprocated it with great respect.

The second time I met him was on a railway train when he was travelling to Bombay. I entered his compartment at Gondia about mid-day and travelled along with him up to Nagpur. It was meal-time and the Knight intimated to me that his kitchen was on the train with a cook to supervise its affairs. Without moving from his seat he then pointed to a stove, which formed his whole kitchen, introducing at the same time the Superintendent of the Chemical Works as his cook—an honour which his chemist pupil seemed to be proud of. This exalted cook took no time to prepare the full menu for his master, which consisted of a very small quantity of rice, supplemented later on with a single plantain fruit. I wondered whether that was some sort of chemical food, capable of maintaining a person on so small a quantity. After showing me this magic he related how he washed his own clothes and managed to do it even at Sir Bipin Krishna Bose's, where he was surrounded by servants, who would not give him an opportunity to have his own way. I asked him whether he had informed Sir

Bipin about his journey to Bombay. He replied that he did not do it, as he was afraid he might be asked to do justice to food bond to be brought for him, knowing that he would not be able to take it on account of its richness. On this occasion I had before me an example of plain living and high thinking.

The third time we met at Nagpur in a meeting recently called for determining how the bequest of 35 lakhs made by a philanthropist of my province may best be utilized. There he expounded the practical view, which his mature experience dictated, as against theoretical suggestions made mostly by his own pupils, one of whom, the most eminent, who had been honoured by his admission to the Fellowship of the Royal Society, received a wrap on his venturing to interrupt him while he was speaking—a wrap which elicited a rapturous smile from the recepient, as it did from the rest of the Committee. It showed the profound respect, which not only his pupils but others outside that circle held him in.

For a person so benevolent, so kind, so learned, so unselfish, so devoted to duty, so universally loved and so profoundly respected I fail to find a suitable epithet but that of MAN. May he live long to furnish a model of humanity to the coming generations.

Modern Science and its Influence on some of the Philosophical thoughts of the present century

By A. C. Banerji (Allahabad).

In this article an attempt has been made to exlpain briefly and in a popular language some of the modern theories of physical science and interpret the far-reaching changes which they have brought about on our outlook of the universe and some of the philosophical concepts of the present day. During the last thirty years, progress of science has been very rapid. It has been much more far-reaching and revolutionary in character during this period than during the whole period of the last three centuries. There was a distinct tendency or rather a movement amongst the scientists of the last century to interpret the whole universe as a machine. This movement reached its culmination in the latter half of the last century. It was the mechanical age—the age of the engineer scientist, whose ultimate aim was to make different models of Nature in her different aspects. Helmholtz, the German scientist, declared "that the final aim of all natural science is to resolve itself into mechanics." Lord Kelvin frankly admitted that he could not understand anything which could not be made into a mechanical model. This concept of Nature greatly influenced the philosophical ideas of that age. This was the age when the law of causality reigned supreme, which was thought to guide the course of the natural world. It was confidently proclaimed that Nature could pursue only one path, i.e., "the path which was mapped out for her from the beginning of time to its end by a continuous chain of cause and effect." It is quite evident that the idea of continuity is also involved in this law of causation. The success of the mechanical interpretation of nature by means of the law of causality continued unabated for a long time and

it became more and more difficult to believe in free will. But in the closing years of the nineteenth century tremendous difficulties were experienced in the interpretation of certain phenomena by means of prevalent classical theories based on the law of causation and also on the law of continuity.

A black body is one which is thought to absorb or radiate heat or light. This body cannot reflect or transmit heat or light through it. We can imagine a box-like structure covered on all sides by lamp-soot. Classical scientists could never think that heat or light energy can only be absorbed or emitted in indivisible units called quanta which can no longer be subdivided, and that the total heat or light absorbed or emitted by such a black body is an integral multiple of the quantum (whose magnitude depends upon the frequency of the particular light or heat vibration concerned). These scientists thought that light or heat energy can be absorbed or emitted in indefinitely small quantities. On the basis of this assumption certain classical formulae were deduced to indicate the energy radiated from the black body. Experiments were performed by Lummer and Pringsheim to see if the experimental results tallied with the classical formulae. It was found that especially for short wave-lengths (of energy), the results differed very materially from the formulae used. It was left to Max Planck to formulate his famous Quantum Theory mentioned above in 1900 and to give the right formula for black-body radiation. It is as if heat or light energy is emitted or absorbed in indivisible units (or particles) by tiny jumps or jerks. This theory therefore involves the principle of discontinuity, i.e. we cannot continuously go on subdividing heat or light quantum into smaller and smaller bits.

During the last century Dalton's Atomic Theory was universally accepted. It was assumed that there were about 92 elements, each of which can be ultimately divided into indivisible units called atoms, which could no longer be subdivided. It may be mentioned that some sort of law of discontinuity also holds here. Sir J. J. Thomson, Sir William Crookes and others passed electric currents at high potentials through tubes containing gases at low pressures.

Cathode plates of various elements and various gases were used and it was found that in every case, whatever be the metal used for the cathode and whatever be the gas used, electrons were always shot out from the cathode plate. This conclusively proved that the electron which is the unit of negative electricity is the common constituent of all matter, and thus the theory of the indivisibility of atoms received a death blow.

Becquerel first discovered in 1896 the phenomena of radioactivity in comopunds of uranium, which gave out spontaneous emanations and changed ultimately into compounds of lead which is of lower atomic weight. In 1898 Madame Curie isolated radium. Later on, thorium and uranium were isolated. These are radio-active substances which ultimately change into lead of lower atomic weight by spontaneous emanations of α rays, β rays and γ rays. It was found that α rays consist of double units of positive electricity (called protons), β rays consist of negative units of electricity which are called electrons and γ rays were found to consist of quanta of light called photons. Later on Lord Rutherford showed that protons and electrons are two fundamental constituents of matter. His experiments indicated that each atom approximates to a miniature solar system. The unit of positive electricity which is called the proton is much more massive than the electron, i.e. about 1800 times as heavy as the electron. The positive charge is at one of the foci and the electrons are describing circular and elliptic orbits round the centre or one focus. The hydrogen has one proton at the focus and one electron is going round one orbit. The helium atom has two electrons moving round the orbits and the positive nucleus consists of four protons and two electrons. The helium has atomic number 2, so only two electrons can go round the orbits. But its atomic weight is almost four, i.e. it is almost four times as heavy as the hydrogen atom.

It is a matter of common observation that when sunlight is passed through a glass prism, it is dissected into a band of seven main colours (red, orange, yellow, green, blue, indigo and violet) called its spectrum. It is a continuous band. It is also found that incandescent hydrogen gas will emit light, which

when dissected is found to consist of certain definite bright lines in different parts of the spectrum. There is no continuous spectrum for it. Similarly helium will emit certain bright lines called helium lines. Similarly for other elements. For the sake of simplicity now let us take the constitution of the hydrogen atom. There are only certain definite orbits along which the electron can move round the positive nucleus, the electron cannot take any of the intervening orbits. These definite orbits are called the quantised orbits and they indicate the stationary states of the atom. These different stationary states indicate different *energy levels* of the atom. By outside influence, such as heat etc., the electron may be made to jump from one quantised orbit across the intervening space to another quantised orbit. If it jumps from an orbit of higher energy level to an orbit of lower energy level the residual energy is emitted in quanta of light of certain definite frequency, and a bright spectral line is seen. Similarly due to jumps between different quantised orbits different spectral lines are formed. No continuous spectrum band can be formed as the infinite number of geometrically possible orbits spreading continuously over space are not all quantised orbits, i.e. the orbits along which only the electrons are destined to move. Similarly for other atoms. This is what we generally call Bohr's theory. In these jumps there is a good deal of uncertainty or indeterminateness. One cannot say definitely to which of the various quantised orbits the electron will ultimately jump from the present orbit. The electron may go from state A to state B or to state C or state D, but no body can say for certainty to which it must necessarily go. But it is possible to calculate mathematically its probability of jumping over to various states. We may determine that the probability of going from state A to state B is greater than that of going from A to C, and the probability of going from A to C is greater than that of going from A to D and so on. It is also quite clear that the principle of discontinuity holds good here in a very marked degree as the electrons jump over the intervening space. So no continuous spectrum band is possible for light emitted by different elements and that this light

when analysed must consist of certain definite and discrete bright lines. This shows that many natural phenomena occur by discontinuous processes. We have now begun to see that the law of causality and determination is gradually giving way to the principles of indetermination and discontinuity, and that the law of probability is pushing on with great force and making its way clear for universal acceptance.

Now we shall try to explain the theory of Relativity. In 1928, Einstein, then a youngman of 26 years of age, first revealed his special theory of relativity. It was at first submitted by him for his doctorate degree. But his examiners failed to understand or realise the true significance of it and the thesis was rejected. Next year he submitted his thesis on a more commonplace subject which was intellegible to his examiners, and he got his doctorate degree. The special theory may be explained in a simple manner in the following way :—

If a train runs at the rate of 40 miles per hour eastward and a man travels at the rate of 4 miles per hour in the same eastward direction, then the velocity of the train relative to the man is 36 miles an hour. If the man instead of going eastward walks westward at the rate of 4 miles per hour, then the velocity of the train relative to the man would be 44 miles per hour. The idea underlying this is that there is some thing in the universe which is at absolute rest. When we say that the train is moving at the rate of 40 miles per hour, we mean it is moving with respect to something which is absolutely at rest. Similarly the man is supposed to travel 4 miles per hour with respect to something which is absolutely at rest.

The velocity of light is about 186,000 miles per sec. The earth at any particular moment is supposed to be moving in space in a certain direction with a velocity of about 19 miles per second. Michelson and Morley performed very delicate experiments by passing beams of light in different directions in order to find the velocity of light relative to that of the earth in different directions. If it is possible to have any body in this world which is absolutely at rest and if the above velocities of light and earth are the absolute

velocities, i.e. velocities with respect to the body absolutely at rest, then the magnitudes of the measured relative velocities should be different from one another and also from the velocity of light itself. But no such difference in magnitude was found, and the relative velocity was found to be equal to the velocity of light itself. The experiment was repeated six months later when the earth was supposed to be moving exactly in the opposite direction, i.e. the velocity of the earth was thereby changed by 38 miles per sec. Exactly similar results were obtained. This apparent paradox has to be explained. To explain this the classical idea of "absolute rest" and "motion" had to be abandoned. There is nothing in this universe which has got absolute motion. Moveover, we have found that relative velocity of light with respect to the velocity of another body in motion is the velocity of light itself. This shows that the velocity of light plays a very fundamental part in our universe. Now it was found that by means of a few mathematical devices certain equations could be constructed in which the velocity of light c would play an important part and form which it would be possible to deduce mathematically that the relative velocity of light with respect to any other velocity would be the velocity of light itself. These equations are nothing but Lorentz transformations. To obtain them certain assumptions are necessary. Formerly we thought of space as something which existed around us in three dimensions and of time as something which flowed past us. The two seemed to be in every way fundamentally different. We could retrace our steps back in space but never in time. We could move quickly or slowly or not at all in space as we chose, but we could never regulate the flow of time. This was the classical idea which we have to give up now, and instead of this we have to assume that space and time are welded together so thoroughly that it would be impossible to detect any trace of join in them. So we have to use a four dimensional continuum (three for space and one for time) instead of three as in the case of space in order to get our equations. I cannot resist the temptation of quoting the formula for the relative velocity of two bodies in motion. The formula is very simple. If v and u are the velocities of two bodies, then

the relative velocity between them is given by $v_r = \dfrac{v-u}{1-\dfrac{vu}{c^2}}$.

where c is the velocity of light.

If one of the velocities is the velocity of light, say $v=c$, then we find

$$v_r = c$$

i.e. the velocity of light relative to another body is the velocity of light itself. For the motion of bodies which we ordinarily meet, as v and u are very small compared to c, we get

$$v_r = v - u \quad \text{approx.}$$

In 1916, Einstein disclosed his general theory of relativity. The reasons which necessitated a new theory which replaced Newton's theory of gravitation may be stated as follows: —

It is a matter of common observation that a planet moves along an elliptic orbit round the sun at one of the foci. The nearest point on the orbit from the sun is called the perihelion and the farthest point is called the aphelion. According to the Newton's theory unless disturbed by any neighbouring big mass the perihelion of the orbit should be fixed with reference to the sun. It is found that in the case of the planet Mercury the perihelion of its orbit is advancing in the same direction as Mercury itself by a marked amount. The same phenomenon is noticed to a lesser degree in the case of the planets Venus, Earth and Mars. But these observational effects cannot be explained by Newton's theory unless there be heavenly bodies of considerable mass near about these planets to produce these motions of the perihelions, but no such masses have been observed. Moreover, we have already seen that we have been compelled to discard the old theory about a body having absolute motion. Now the task before us is to formulate a new theory which would be able to explain equally well, if not in a better way, the phenomena which have already been explained by the Newton's theory. Moreover our new theory ought to be able to explain those observed facts like the advance of the

perihelion of Mercury, which could not be explained by the Newton's theory. Again the reason for accepting the new theory would become stronger if it can predict certain phenomena, which can be observed and verified. Now Einstein's theory of relativity fulfils all these conditions. The theory predicted that a ray of light near the sun should get curved. For a ray grazing the sun's limb the deflection should be $1''\cdot75$. At the time of any total solar eclipse photographs of the sun and rays from a star near about the sun's limb can be taken and the prediction tested. The prediction was verified and the amount of observed deflection was in accordance with the theory. The recent observation shows that the deflection is about $2''\cdot5$ instead of $1''\cdot75$. This necessitates a different value for the cosmic constant λ in Einstein's equation.

There was another prediction about the displacement of Fraunhofer's lines in the solar spectrum. But it is very technical, and the verdict of recent experiments is distinctly favourable to Einstein's theory. The old gravitational theory of Newton was a science of forces which were supposed to be inherent in nature, whereas Einstein's Relativity is really a science of Geometry. When two bodies approach due to their motions and relative configurations, there is no harm if we speak subjectively about their gravitational pull, but one should be careful about using such a term objectively.

If space-time continuum has all along been uniform, then if a certain set of equations holds true at one point of the continuum, it will also be true at any other point of the continuum, i.e. this set of equations will be uniformly true all along the continuum. But if there are irregularities or non-uniformities (moving) at certain spots of the continuum, then these uniform equations would get modified at these spots. We may say that masses are nothing but non-uniformities in otherwise uniform continuum and these modified equations are nothing but Einstein's so-called gravitational equations. There is one intrinsic property of Nature, viz., that if a point (or call it more accurately a point-event) is placed somewhere in the continuum, it will geometrically chalk out amidst the (moving) neighbouring masses such a path along which it will

experience (as it were) the least resistance. Such a path is called in geometry the "Geodesic."

It can be explained very simply and popularly, but not rigorously in the following way:

If there are two points A and B on a plane surface and if there be no obstruction between them, then the path of least resistance between them will be the straight line between them. But if there is a steep hill between A and B then the path of least resistance will bend round the hill.

On the surface of a sphere the geodesic between two points is the arc of the great circle between them. A plane intersects a sphere along a circle, and if the plane passes through the centre of the sphere then the circle is a great circle. For finite distances or for terrestrial distances Newton's formula and Einstein's formula differ by a very small quantity, but when we deal with great astronomical distances the difference between these two formulae becomes very marked, and in such cases we have to use Einstein's formula. Also in very small regions or subatomic regions, i.e. when we study the nuclei of atoms, we find that Newton's Dynamics fails there: and the phenomena which we observe there have to be explained by Schrodinger's Wave Mechanics and Heisenburg's New Quantum Mechanics with the help of Relativity. We shall have to stick to the theory of relativity so long as we cannot get a better theory which will explain all that the theory of relativity has been able to explain and also all that Relativity has failed to explain. Indeed with the advent of Relativity the age of the mechanical science has passed away. It has also brought about a tremendous change in the viewpoint of many philosophical notions of the last century. Moreover, mechanical media like the ether do not seem to be a necessity now. Many careful experiments have been performed to detect the motion of the earth through ether but without any success. So if there be any ether at all the upshot of such experiments is that the forces of nature seemed without exception to be parties to a perfectly organised conspiracy to conceal earth's motion through ether. Perhaps it was necessary for the scientists of the

Newton school, who believed in the theory of absolute motion, to conceive an all-pervading ether which must be at rest, but as the new group of scientists belonging to the Relativity school believe that there is nothing in the universe which can be at absolute rest the necessity for having ether has disappeared. As the absolute position of a point-event cannot be known, and perhaps it has no meaning at all, so the theory of relativity has helped in dethroning the law of causation from the position it held as the only one guiding the course of the natural world.

Let us now study the circumstances which led to the introduction of Wave Mechanics.

If we have a source of light, and a big object in front of it, such as a table, a desk, a chair, or a house, a definite shadow is throw on a screen beyond, but a tiny object, such as a very thin wire, hair or a fibre, throws no such shadow. If the object is held in front of a screen no part of the screen remains unilluminated. In some way light contrives to bend round it like a wave and instead of a definite shadow we get alternations of light and comparatively dark parallel bands. These are called interference bands. Similarly a large circular hole on a screen lets through it a circular patch of light on the screen beyond; but if you make a very small pinhole then the pattern thrown on a screen beyond is not a tiny circular patch of light but a large pattern of concentric rings, in which light and dark rings alternate,—these are called "diffraction rings." This is due to the wavy character of light. Again Prof. Compton's experiment showing that X-ray radiation falling on electrons is scattered by them proves that radiation also consists of material particles of light or photons or light quanta, which proceed in straight lines. Also it is a known fact that a photographic plate gains very slightly in weight when it is exposed to sun light on acconut of the weight of the light particles absorbed by silver bromide. All these show that light is both wavy and corpuscular in character. Now light behaves like particles, and now it behaves like waves; no general principle is yet known which can tell us what behaviours it will choose in any particular instance. So there is some uncertainty or indeterminateness here. Perhaps

we can preserve our belief in the uniformity of nature by supposing that particles and waves are essentially the same thing. Let us now see how far our supposition is justified. Electrons and protons are essentially particles, but we see that sometimes they also behave like waves. Indeed experiments were performed by Prof. Thomson of Aberdeen in 1925, who got diffraction rings produced by electrons passing through a minute area of a gold film. This unmistakably proves the wavy character of the electrons. Prof. Dempster of Chicago performed a similar experiment with protons. It seems, therefore, that ingredients of matter (proton and electron) and radiation (light) exhibit dual nature. As pointed out by G. Darwin it is an example of principle of duality in science. These dual characters on the part of the electron or the proton are not really contradictory. We have only to recognise that experiments which evoke the particle-character of the electron and the experiments which evoke the wave-character of the electron are mutually exclusive. Experiments designed to show the particle character cannot enlighten us anything about its wave character and vice versa. There is really no conflict between the two differing characters of the electron or proton. It is a case of fundamental duality. When the electron behaves as a particle it discloses its discrete character, and when it behaves like a wave, which involves continuity as well, it discloses its non-discrete character. The principle of duality is new in scientific thought, but it has already been accepted in Metaphysics. There is the duality between the subjective and the objective, that is, there is fundamental difference between the abstract scientific conception of heat and the much more poignant realisation when we burn our finger due to heat in fire. There is also a fundamental difference between the idea of light as a sort of wave propagation, say of wave-length 1/20000 of a centimetre, and the actual perception of green light.

So long as only large-scale phenomena are concerned an adequate picture can be obtained by supposing them to have been produced by particles; but when science passes on to the study of small-scale phenomena, matter and radiation are found to resolve themselves into waves. Louis de Broglie of Paris and Schrodinger

of Germany have imagined electrons and protons to be systems of wave-centres from which groups of waves emanate. They have founded that branch of mathematical physics which is called Wave-mechanics. No one can assert "I can see the electron and clearly it is not a system of waves," for not one has ever seen an electron or has really the remotest conception as to what it looks like, whereas on the other hand Thomson's and Dempster's experiments have shown that diffraction rings of electrons and protons can be formed. In wave-mechanics we also calculate probabilities, we say that electrons and protons are at those points where the probabilities are maximum for the centres of emanations of waves to exist.

But the principles of indetermination achieved its crowning glory when Heisenburg formulated his New Quantum Mechanics. He dealt with the statistics of discrete quantities and so he had to make use of the "Theory of Groups" or the "Theory of Matrices." Heisenburg's principle is known as "the principle of indetermination." The law of causation has now lost its supreme position. G. Darwin has thus explained Heisenburg's principle of indetermination : "The main character of a wave is its wavelength, i.e. the distance between the successive crests of the wave, whereas the main characters of a particle are its position and speed. There is a simple relation between the speed of the particle aspect of the electron (or proton) and the wavelength of its wave aspect. They are inversely proportional, i.e. the slower the electron the greater is its wavelength.

"A wave of wavelength λ cm. does not by any means imply two crests λ cm. apart, but it means a regular train with crests spaced at intervals of λ cm. and spreading to infinity in both directions." It involves the idea of continuity, and its non-discrete aspect cannot be overlooked.

To crystallise our idea let us take for the moment a "wave packet" instead of wave motion spreading to infinity. A wave packet may be supposed to be composed of a number of crests at equal intervals surrounded on both sides by quiet region. If this wave packet represents an electron wave, then we may say that

the electron particle is somewhere within the packet, and we can definitely assert that it cannot be anywhere within the undisturbed region outside the packet. As the packet of waves advances it spreads so as to increase gradually in size. The rate at which it increases depends upon its size. A long packet with many crests will spread slowly and a short packet containing just a few crests will spread rapidly. The wave is spreading and the particle may be anywhere in the packets. If the particle is moving at the head of the packet, it would be moving faster than if it had moved with the tail. The particle would be going still faster if it had started at the tail and ended at the head. So along with the position, the speed of the particle is to some extent uncertain. In a very long packet, the position of the particle is very uncertain but as such a packet spreads very slowly the speed is rather precise. In the case of a short packet the position is rather precise but as it spreads very rapidly its speed is very uncertain. Mathematically the product of these two uncertainties is found to be almost equal to one. It can be mathematically calculated that if $\lambda = 7$ cm. then such a wave system will correspond to a particle which would move at the rate of 1cm. per sec. The question is where in all this wide region is the particle? The answer is that it may be anywhere. At first it appears to be contradictory to common sense and one is apt to think that after all it must be somewhere, and there should be something corresponding to it in the wave aspect. But we shall see presently that there is sense in this aspect of uncertainty.

So we have seen that instead of certainties we have to deal with probabilities and the theory of chance has been raised to a more important position than what it used to occupy before. Closely associated with the principle of uncertainty is the question of free will. G. Darwin has very aptly pointed out that there are two radically different types of the free will—say, my free will and your free will. When I think about *my* free will, I conceive myself making definite and arbitrary decisions without reference to any causes whatsoever, such as my decision to raise or lower my hand. When I observe *your* free will it seems to me that

there is capriciousness in your actions, and so far as I am concerned there is a perfect uncertainty as to whether you will raise or lower your hand although you would claim that for yourself you are displaying the same sort of free will as my own free will. But so far as I am concerned your actions have the same sort of uncertainty as that displayed by the electron.

Rutherford and others proved that matter is electrical in structure and all physical phenomena are ultimately electrical. Now wave mechanics has reduced the whole matter in the universe to a system of waves; electrons and protons behave as groups of one kind of wave emanations, and radiation consists of another kind of waves. If that is so, transformation of protons and electrons into light energy or photon is possible. If an electron and a proton in free state come together and collide with tremendous speed, the positive and the negative charges will be neutralised and it is quite conceivable that the combined mass will be transformed wholesale into light energy, i.e., a light proton.

Now radiant energy consists of waves which travel with the velocity of light, whereas matter waves travel more or less slowly. Jeans has mentioned that radiation is perhaps matter moving with the velocity of light, where matter is nothing but radiation moving with a speed less than the velocity of light; or it can be said that matter is congealed radiation or bottled up waves, whereas radiation is free and unbottled wave moving with the velocity of light.

Now the theory of the expanding universe will be briefly discussed. According to the theory of relativity the space-time continuously gets curved due to matter inside it, just in the same way as the surface of the earth is curved (or feely gravitating matter gets the curved spherical form). Just as a curved line (which is of one dimension) on the surface of a sphere or the surface itself (which is of two dimensions) is embedded on the sphere which is of three dimensions, so we can imagine that our space-time world is embedded as a bounding surface of an enclosed region of a continuum of more than four dimensions and which continuum may extend to infinite in all directions. A universe entirely devoid of matter would have its space-

time continuum entirely uncurved, as there will be no matter to bend it and perhaps it will be of infinite size. As the universe is not empty, its size and shape will be determined by the amount of matter it contains.

Now Einstein's law of gravitation contains a cosmical term which physically represents repulsion directly proportional to distance. For smaller distances or in ordinary application to solar system it can be neglected, but for sufficiently great distances it becomes repulsion. This is what may be called the cosmic repulsion and we shall try to give a physical interpretation of it later on. It seems likely that our universe started with a balance between gravitational attraction and cosmic repulsion. This static universe is the so-called Einstein's universe. Abeé Le Maître, a Belgian mathematician, has shewn that such a universe is unstable and cannot stay at rest for long. The slightest disturbance would cause either repulsion or gravitational pull (used subjectively) to get the upperhand. So the universe would start at once to expand to infinite size or to contract to a nucleus. De Sitter of Leiden also discovered separately from mathematical calculations the tendency of our universe to expand or contract. It is a known fact that the noise emitted by a motor car horn or the whistle of a railway engine sounds lower in pitch when it is receding from us. On the same principle the light emitted by a receding body appears lower in frequency or redder in colour than that emitted by a body relatively at rest. In the case of an approaching body the shift of the spectral line will be towards the violet. By accurately measuring the shift of well-defined spectral lines of the light emitted by an approaching or a receding body the velocity of approach or of recession of the body can be found out.

Dr. Hubble of Mount Wilson Observatory found from the amount of shift of the lines towards the red that a nebula, which is ten million light years away has a speed of recession of 900 miles per sec. A light year is the distance which the light takes a year to travel— it is an astronomical unit of distance for very great distances. It is also found that the remotest spiral nebulae have

perhaps a speed of recession of about 12,000 miles per sec. If this be true then Eddington calculated that our universe is expanding to double its dimensions in every 1,400 million years, and that the original radius of the Einstein universe before it started to expand was only 1,200 million light years. From this calculation the age of our universe could not be more than a few thousand million years. This is too short a period for the age of our universe, and the geologists, after calculating from the time taken by radio-active substances found on the earth to disintegrate themselves completely, give a much greater period for the age of the earth and the universe. Calculations made by geologists from physical data are certainly more reliable.

Let us now find out the cause of discordance between these two calculations giving the age of this earth. Another cause of the reddening of the light emitted by nebulae has been suggested by Dr. Zwicky of Californian Institute. His idea is that the reddening may be due to the gravitational pull of stars and nebulae as light passes near them. Compton's experiments also show that radiation when it falls on electrons in space is deflected as well as reddened due to encounter. Ten Bruggencate has examined the light emitted by a number of globular clusters all more or less at equal distances from us, but they were so chosen that the amount of intervening gravitational matter through which light had to pass varied greatly in the case of different clusters. He found that the reddening of light emitted by different clusters was not at all uniform.

The most plausible theory for reconciling the apparent discordance in the two calculations of the age of the universe seems to be that possibly most of the reddening of the spectral lines are due to the effect suggested by Zwicky and only a small residual amount represents a real motion of recession or the expansion of the universe. Then and then only it would be possible for our universe to have a long life of millions of millions years, quite in keeping with the geological evidence.

Several other difficulties also arise in connection with the theory of the expanding universe. Calculating on the basis

of this theory, a nebula which has receded to a distance of 1,800 million light years ought to have the limiting velocity equal to that of light. Now as matter in this physical universe cannot have any velocity greater than the velocity of light, one can naturally ask what will happen next. It has been suggested that matter possessing velocity greater than the velocity of light belongs to a different disconnected world which cannot bear any physical relation to us. This is only a suggestion which cannot possibly be verified at present. Now mass of a receding nebula becomes infinite when in the limit it attains the velocity of light, and one may reasonably ask how this tremendous increase in the mass has been brought about?

These are the difficulties which have not yet been satisfactorily explained.

Now let us try to give some sort of physical explanation for the cosmic repulsion. It has been discovered that a kind of highly penetrating radiation called the cosmic radiation now falls on the earth. This radiation can penetrate several yards of lead. It is a known fact that ultra-violet light can penetrate farther through the skin than the ordinary sunlight. X-rays have a still greater penetrating power than ultra-violet rays, but nothing yet has been found to be so penetrating as the cosmic radiation. It is found that high pitch in radiation is accompanied by the highly penetrating power of going through the solid matter. In the words of Jeans it is as if the waves wriggled so rapidly (the frequency being very high) that the atoms could not stop them. Violet light is one octave higher than the red light and cosmic radiation is 28 octaves higher than the red light.

Our sun is at a temperature of 50 million degrees at the centre. Many of the stars are more or less at the same temperature or even at a higher temperature. Many electrons and protons may be in free state there, and are moving about with tremendous speed. Jeans suggests that very frequently an electron and a proton come together and collide with tremendous force on account of very high speed. The positive and the negative charges become neutralised and the combined mass is completely

transformed into radiant energy or a photon and this radiant energy comes to us in the shape of cosmic radiation. As more and more cosmic radiation is produced cosmic pressure increases and the bounding surface of the universe expands. But there is one strong point against Jeans' theory of production of cosmic radiation. If collision be the only cause of cosmic radiation then the intensity of cosmic radiation cannot be uniform in all directions in high altitudes as observed by Prof. Piccard. It should be most intense in the direction in which the number of stars is greatest. Prof. Millikan found also that on the earth's surface the intensity of cosmic radiation is uniform in all directions. He performed experiments during the night and during the day and during different seasons as well, but he found the intensity of radiation to be more or less uniform. Prof. Millikan's experiments were not so accurate as those performed by Prof. Compton. Prof. Millikan considers that cosmic radiation may originate as a by-product in the process by which heavy atoms are formed by combination of light atoms i.e. we can say that "the Creator is still on His job." If the universe has expanded from a congested nucleus of matter, there is no spot within the universe which can be absolutely devoid of matter. But the density of matter or primeval gas is very rare between inter-stellar space. Now condensation may start at a point in inter-stellar space by formation of heavy elements from light elements. Now when four hydrogen atoms combine to form a helium atom, the mass of the newly created helium atom is 3·97 times and not four times the mass of the hydrogen atom. Prof. Milikan suggests that the residual mass i.e. ·03 of the mass of the hydrogen atom is transformed into radiant energy to be emitted as cosmic radiation. Dense matter occupies comparatively a very small portion of the universe, and formation of heavier elements from higher elements may be going on very frequently and symmetrically around us in the inter-stellar space where density of gas is very low and the various elements may be in gaseous as well as in nascent state.

This process will give us more or less uniform cosmic radiation from all directions. But very recent experiments initiated by

Compton, which are more reliable than those of Millikan, show that there is a marked change of intensity of the cosmic radiation in different parts of the earth, and that its intensity depends on the magnetic latitude. Such a relation suggests that cosmic rays may consist of swift charged particles instead of mere photons. Prof. Piccard who reached a maximum height of 53,672 ft. in his balloon on August 10, 1932 found that radiations at such great heights was uniform in all directions. He provisionally suggested that the cosmic rays had their origin in stratosphere. There is one good point about Millikan's Theory. Jeans' Theory gives a very dismal picture of the ultimate fate of our universe. According to him all matter will ultimately be transformed into cosmic radiation and no matter will be left in the universe but dead cosmic radiation. But Millikan's theory does not give such a dismal picture, as dense matter is also being created along with the production of cosmic radiation.

Although the law of causality cannot be completely discarded, the principle of indetermination and the law of probability now play a very important part in guiding the cause of natural phenomena in our universe. The law of causality has been dethroned from its unassailable position which it held before. The law of probability regulating the spontaneous disintegration of radio-active substances (or the probable jumps of α, β and γ particles) can be explained a little further in the following way.

Jeans has compared the atom of a radio-active element to a party of four card players who agreed to break up as soon as each player receives one complete suit. A very big hall containing a great number (in reality millions) of such parties may be taken to represent a mass of radio-active substance. It is possible to show mathematically that if the cards are well shuffled before each deal the number of card parties will become smaller and smaller according to the exact law of radio-active decay. Here the shuffler of card may be compared to the so-called fate.

There is a group of mechanical scientists who think that life including intelligent life or consciousness has been created out of inert matter by means of certain chemical and physical processes.

They believe ultimately that man will be able to create life including intelligent life by such processes. They take inert matter to be the fundamental or the primeval thing. Let us examine this question more thoroughly. There are only three alternative hypotheses that are possible.

(1) Inert matter is the only primeval thing that existed in the beginning of this world.

(2) Inert matter and life (in the shape of sperms) are the two primeval things which existed independently in the beginning.

(3) Inert matter and life (in the shape of sperms) and consciousness are the three primeval things that existed independently in the beginning.

The first hypothesis is clearly the one which is most unfavourable to the conception of world consciousness. Let us take it to be granted that inert matter was the only fundamental thing that existed in the beginning, then life and intelligent life which we see now must have been created out of inert matter by *self-evolutionary* physical and chemical processes. I say that the processes are self-evolutionary, as from the very nature of the hypothesis no outside agency could have been responsible for them. So it is quite possible that out of the totality of matter in this universe an enveloping world consciousness might have been evolved by the same sort of chemical and physical processes. Modern science is now guided by the law of probability, and no engineer, scientist or so-called mechanical scientist or the materialist can, in my humble opinion, logically or scientifically totally exclude the possibility of any such world consciousness as some of them did in the last century and in the beginning of the present century. The probability of the evolution of a world consciousness may be great or small, but it is not nil. No mechanical scientist can dare assert that such a probability must be nil.

If we take the second hypothesis we can easily see that the probability of the evolution of a world consciousness out of the totality of life sperms cannot be nil. In the third hypothesis we automatically admit the existence of a primeval world consciousness.

It is said that Napoleon used to ask, "If God created this universe, who created God." In my opinion there can be only two alternative hypotheses for the creation of this universe. Either the universe has evolved out of itself or some powerful external agency has created it. If it is possible for inert matter to evolve out of itself, it is all the more possible for an all-powerful conscious agency to evolve out of itself. So there is a great possibility of the universe being created by some external powerful and conscious agency which has evolved out of itself (स्वयम्भु). We know that the circulation of blood and respiration both of which seem so natural are functioning automatically in the human system but they are controlled by some active brain-centre; so it is quite possible that the laws of Nature which appear so automatic are controlled by some world force or consciousness.

Voice of Insects

By Durgadas Mukerji (Calcutta).

The evolution of a parallel type of social structure in the insects and the higher vertebrates can easily be understood by drawing a comparison of some aspects of their social habits.

As immense time and change rolled on since their first appearance on the earth in the remote past, the vertebrate series by evolutionary process reached the mammalian stage and culminated in man, while the insect developed into such social forms as ants, bees,—the social organisation of which rivals that of man, and is unparallel in any other class of the animal kingdom. The social insects display in their gregarious habit, division of labour, the care of young, fraternal love, tribal animosity, architecture of building and foraging habit, a proof of what may be called, according as the disposition of our mind, intelligence and finer feelings, of no mean order. Where social life is so much in advance, the existence of faculty of speech can naturally be expected, and the mechanism of the organ of voice deserves more than a passing mention.

While mammals acquire prominence, by virtue of their relation to man, the tiny insects being placed as a thread in the web of life that binds the interests of man occupy a no less important place in the economy of life. Insects yield to man the sweetest of food, namely honey, satisfy his vanity by furnishing him with silk, help him in raising a bounteous crop by pollination of flowers, and teach him moral lessons of the value of self-sacrifice and devotion to community as exemplified by the life of the bees, ants and social wasps. They, on the other hand, wage war against mankind by devastating his crops and levying a heavy toll of death by spreading pestilence

and disease. Their plastic habits have made it possible for them to invade land, water and air; and to-day they by their overwhelming force of number, challenge the supremacy of man and his kindred.

Nevertheless the superiority of man cannot be gainsaid. The phenomenal success of man, however, cannot be ascribed to intelligence and memory alone. With the dawn of man, power of speech came to him as a gift. This capacity of expressing one's thought, ideas and experience in articulate language, to the benefit of others of his kin, opened the way for education and consequent uplift of mankind in the scale of evolution.

The question may, therefore, be asked, do insects too possess a voice. The croaking of frogs, the note of birds, the howling of jackals, and the humming of bees remind us that man has not the exclusive right of speech, but he certainly has a mastery over modulations of voice that are unknown in the domain of the animal world. It is believed, since insects were evolved earlier than the higher vertebrates, that long before frogs croaked, birds sang, or man developed the ethical sense of music the insects proclaimed themselves as the earliest of the terrestrial musicians (Lutz, Insect-sounds, *Bull. Americ. Mus. Nat. Hist.* 1924). In fact, a large number of species of insects, belonging to different orders, is known to produce sounds.

Whatever name—voice, song, or noise—we may give to insect-sounds, it does not matter so much, as the significance of these sounds to insects seems to us partly by reason of our failure to appreciate the difference between them more or less to be the same. The communication of messages or call among individual members of a species by means of production of sound marks a step forward in the progress of the social organisation of animals concerned. The voice guides them to profit by the experience of others in the easiest manner, tells them about the danger and advantages of life and enables them to speak love-language for the attraction of youth. It is, therefore, not an unimportant factor in the struggle for existence.

The ability to produce sound implies on the part of the same

insect the existence of an organ of hearing. The migratory locusts and the crickets which are provided with a mechanism for production of sound possess an auditory organ. In some insects the organ for the production of sound is limited to one sex, the opposite sex playing the role of the listener. The mosquito whose female is eloquent when in love comes under this category. In Cicada the male sings while the female is dumb. Evidently these are instances of sex call. The workers of the Ponerine ant Lobopelta pequeti which are seen in the fields of Bengal to march two abreast (Mukerji, *Jour. Bomb. Nat. Hist.*) when disturbed, raise a hue and cry loud enough to reach human ears, and their sentinels respond by assuming fighting attitude. The virgin queen bee, jealous of her probable rivals, gives vent to her emotions by a war-cry, that is understood by the inmates of the hive and even can be heard by an apiarist. The sound-producing organ, however, is not always known to be correlated with an organ of hearing and *vice versa*. The insect may perceive, for instance, vibrations of air or a disturbance caused by a foot-fall and transmitted through earth, but may be unable to make any noise on its own part. The reverse is equally true. These mean, then, that the individuals of the same species are incapable of communicating with each other by voice. Presumably in such cases if the auditory organ is lacking, the purpose of sound is to frighten foreign enemies. A sphingid larva (caterpillar) in the hills makes a hissing sound on being touched (Lefroy, Insect Life, p. 722, 1909). It should, however, be remembered that if the sound is produced accidentally, that is, without any intention on the part of the insect, as it is likely to happen when the wings are set in rapid vibration during flight or when the insect unwittingly collides against an object, the sound loses all biological significance indicated above. On the contrary, where the insects are believed to be deaf or mute, it is possible that the sound emitted by the insect is of such a pitch as cannot make any impression on human ears, and the auditory organ of the insect, not having had the form of an ear, might have been missed by an observer. This seems so, as the position as well as structure of the auditory organs vary in different species

of insects. Thus, the auditory organ is situated on the sides of the base of abdomen of the migratory locust, on the legs of crickets, and at the base of the antenna in the mosquito. In some the organ of hearing lies hidden within the body. The auditory organ in the first two cases is composed of a drum; in the mosquito the whorls of long hairs in the antenna of the male catch the sound. The essential part of the auditory organ in the insects is not the drum which, if present, acts like a sounding board, but is composed of a microscopic rod floating within a cell at the terminal end of a sensory nerve arising from the ventral nerve cord.

But is voice indispensable? Sense of touch, taste, smell and vision are the primary mechanisms by which an organism can transmit or receive impressions to and from outside. The function of one type of organ, however, can be replaced or supplemented by another. It is believed, if new needs arise as the result of change of conditions of life, a new habit arises to meet the new wants, or rather a newly arisen structure for the purpose of efficiently carrying on a certain function which the new habit demands may lead to the development of a definitive organ.

Ants in general, for example, search food, find their way home, recognise their friends, communicate with each other by maens of antennae or feelers without depending on organ of vision or voice. The workers of the driver ant Dorylus, a species of which I had the pleasure of reporting from Calcutta (*Univ. Jour. Sci. Col.*, 1925), have by their activity made themselves a terror to the underground world where they dwell, and although they are perfectly blind, they move in colonies in search of prey, being guided evidently by sense of smell and touch. Whereas in certain species of ants such as Lobopelta or Sima etc., organ of voice has been evolved in addition to other sensory structures. Paradoxical though it may seem, the possession of the sound-producing organ, inspite of the advantages which it confers upon the possessor, is not an absolute necessity. Poor consolation indeed for the deaf and dumb hexapod creatures!

As to the quality of voice, it may be a faint squeaking, rasping, buzzing or whistling noise, either continuous or inter-

mittent. Anybody who has heard the shrill persistent or rather monotonous chirping of the gryllids that are common in the dwelling houses of Calcutta, or the orchestra of mosquitoes, or the humming of bees need not be told about the specific nature of note of each species. None of these, however, can beat the high pitch of voice of the famous Cicada. Much has been written about the song of Cicada and I would like to add here my observations made while out with a party of students on a zoological excursion at Cox's Bazar on the Chittagong sea-coast. It was towards evening in the hot month of May. We stood on the summit of a hillock. Below was a valley or rather a depression of the earth. The place was rich in vegetation. We heard the united voices of several insects coming up from below. We went down to the valley. But the music suddenly stopped. We learned from Fabre, the great entomologist, that noise from outside did not disturb the song of Cicada, but it did not seem possible either for the songsters, that were far off from us, to see us in a dim light and through the thick foliage of trees. We felt perplexed at the silence and one of my young zoologist friends whispered that it was the hissing noise of snakes! Silence was broken, slowly rather timidly a musician from a distant bush began to sing. Its immediate neighbours joined it and gradually others took up the tune till the whole place was ringing with one shrill voice. It was chorus singing of Cicadas and we could hear one singing close to the place where we had been standing still. We followed the direction of sound. He ceased at once singing, and others in the neighbourhood followed suit till stillness prevailed again. Did he whistle to others announcing the presence of the uninvited guests at the musical soirée? We flashed the torch and could see a winged musician resting on the trunk of a tree. As we drew near he evidently saw us by his big eyes, hopped up higher and at last flew away to a distant bush. The chorus was started again and went on undisturbed. I believe that when Cicadas are in a musical mood, they may stop singing for a while, if disturbed, for the sake of safety, but they would not cease altogether from joining the chorus.

Attempts have been made by various investigators to analyse the sound of insects by the application of the methods of physics. Amplitude and frequency of vibrations of insect sounds have been determined in a few cases and musical notations have been prepared. Several authors claim to have succeeded in stimulating the auditory hairs in the antenna of the male mosquito into vibration by sounding tuning forks, the frequency of which corresponded with that of the note emitted by these insects. In such a case, if the theory of sexual attraction of insects by voice holds true, then the possibility of entrapping injurious insects by artificial sound of suitable pitch cannot be ignored.

The various methods by which sound is known to be produced by insects can be grouped as follows:—(i) By tapping a part of the body against an external object, as for instance, against the wooden wall of its nest. Some of the beetles which burrow in timber make noise in this way. (ii) By rubbing one part of the body against another. Production of sound in this way, therefore, involves the principle of friction. The surfaces which are rubbed against each other are rough and one acts as the file, the other scraper. Sound produced in this way is said to be caused by stridulation. The migratory locust rubs its thigh (femur) which contains pegs, against the hardened edge of its upper wings. In the crickets the upper wing is crossed over the left and the two are set in rapid vibration causing friction between them. In the large Cerambicid beetle the neck is moved over the trunk thus producing a rasping noise. In the ant Lobopelta pequeti the anterior and the posterior portions of the abdomen which are separated by a constriction are moved against each other. (iii) By the rapid vibration of a membrane of a drum, caused by the action of a muscle attached to it. The drum is set in a chamber in the body and is covered by a lid by the opening and closing of which a rhythmic change in the intensity of sound can be effected. This musical instrument is very complicated and is peculiar to Cicada alone. (iv) By the rapid vibration of wings, as in bees, flies, and mosquitoes. The house-fly hums F and vibrates its wings nearly 345 times per second. In the bee which

makes a sound of A the vibrations of wings are approximately at the rate of 440 in a second. (v) By the vibration of a chitinous fold or membrane, caused by a forceful passage of air from the trachea into the spiracles. The buzzing noise of certain flies, the bees and May beetle is believed to be made in this way.

The reality of the existence of the last method, however, has been seriously questioned Comstock, Introduction to Entomology, p. 91, 1925). In view of the importance of this question I give below a brief explanation of this mechanism and would like to discuss elsewhere the controversial points in the light of my own observations.

The insect does not possess, like a higher vertebrate, a lung, or larynx. It contains within its body a system of air-pipes called tracheae which open to the exterior by a definite number of apertures called spiracles or breathing pores. Atmospheric air is conducted through the spiracles into tracheae which send off branches in different directions all over the body, supplying each and every tissue of the body; thus air is brought into direct contact with the tissues of the insect body so as to feed the tissues with oxygen. The used up air is led back and exhaled through spiracles. In the higher vertebrate, air is drawn through the windpipe into the lung, but cannot directly pass from there into other tissues of the body. In such a case blood corpuscles flow into the lung and fix there oxygen. On their return journey these seek out different tissues in order to supply them with oxygen they carry. Inspite of this difference in respiration, the process of producing sound by the emission of respiratory air in the insects and higher vertebrates seems analogous. In the higher vertebrate the voice is caused by the vibration of the vocal cords set in by a current of air which is forced out of the lung into the windpipe and larynx. In the insects the air contained in the trachea when forcibly driven to the exterior through a spiracle would similarly set into vibration a fold or membrane hanging inside the spiracle or in the trachea and thus lead to the production of sound. Those insects which are endowed with this type of mechanism, therefore, can be said to possess a true voice, compar-

able to that of man and the higher vertebrates. But if the doubts about the reality of the existence of this method in the insect as a class be well founded, the term voice, in the strict sense, would appear to be inappropriate.

Landois in his classical paper (*Zs. Wiss. Zool.* 1867) proved the existence of the afore-said type of mechanism. He removed the wings of insects and showed that sound was accompanied by the emission of air from the spiracle. The authors of the opposite

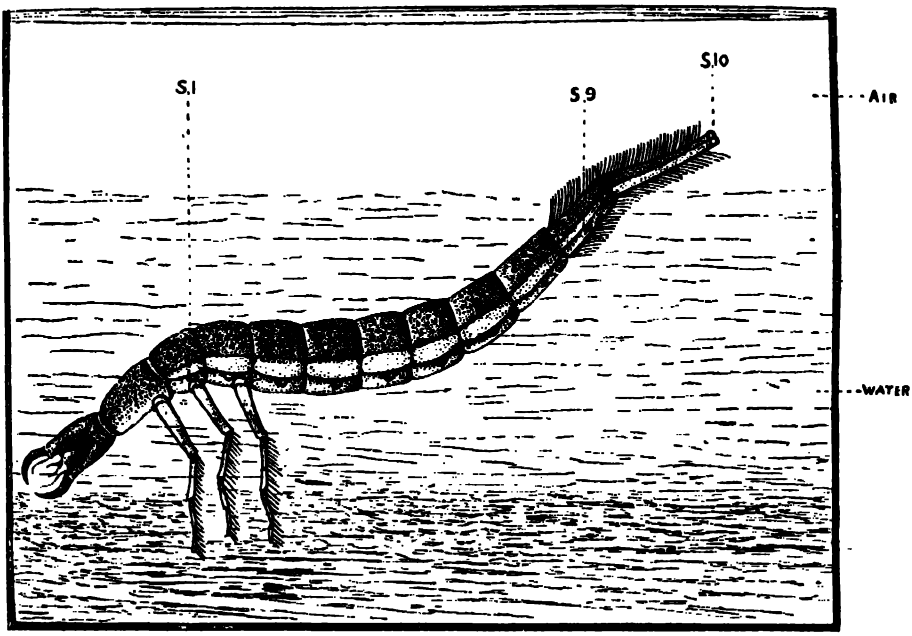


Fig. 1.—Diagram of the *Cybister* larva, showing its methods of respiration by raising the tip of the tail containing the terminal pair of spiracles above the surface of the water. Note the lateral series of spiracles on the side of the body.

s_1, mesothoracic spiracle; s_9, 7th abdominal spiracle; s_{10}, the terminal spiracles.

school (*vide* Comstock, Introduction to Entomology) who denied *in toto* the existence of such a mechanism maintained that sound produced after the removal of the wings was caused by the stump of the wing-base left inside the body, or upheld the view that it was caused by the changes in the contour of the thorax due to the action of the powerful wing musculature.

No decision can, however, be arrived at as the previous authors experimented on insects provided with wings and it was hard to

disprove that the wing-base hidden inside the body did not cause sound by its action.

A reconciliation of the rival theories would, however, be possible if an insect be found which should be devoid of wings and without any wing musculature, and could emit a note by the escape of tracheal air through spiracles. This happy condition was observed by me in the larva of the large aquatic beetle Cybister of the Dytiscidae family (*Journ. Bom. Nat. Hist.* 1930).

The larva had this additional avantage that though it was aquatic in habit, it retained the terrestrial mode of respiration, and therefore, production of sound by the emission of air through spiracles could be demonstrated by immersing the live specimen under water without hurting the animal. It may be noted that previous authors considered these lateral spiracles closed and naturally missed the points discussed here.

Later on I made a detailed study of the respiratory system including the minute anatomy and function of the spiracles of the Cybister larva and came to the conclusion that all the spiracles were open and that sound was produced by the mesothoracic spiracles alone when the body was flexed in the middle region (*Achiv. Zool. Expt. Paris,* 1930).

As the sound-production in this insect larva throws much light on the disputed question, a brief explanation of its respiratory system and the mechanism of sound-production is given below.

In the Cybister larva there are ten pairs of spiracles serially arranged on the body (fig. 1, s_1- s_{10}). Of these nine pairs occur on the side and are called lateral spiracles. These are distributed as follows : (a) two pairs on the thorax,—of which the 1st pair (counting from the anterior, i.e. the head end) is known as the mesothoracic spiracles (fig. 3, s_1) : (b) seven pairs on the abdomen (fig. 1, 3, s_2- s_9). The tenth pair also belongs to the abdomen and is peculiar in being situated at the tip of the tail end of the larva and hence indicated here as the terminal spiracles (fig. 1, s_{10}). The terminal spiracles are periodically raised above the surface of water for taking in and giving out air for respiration (fig. 1). Now it has been reported by me that the mesothoracic spiracles (i.e. the

first pair) emit sound when the larva is attacked. It may, therefore, be asked why other spiracles, which are open like the first

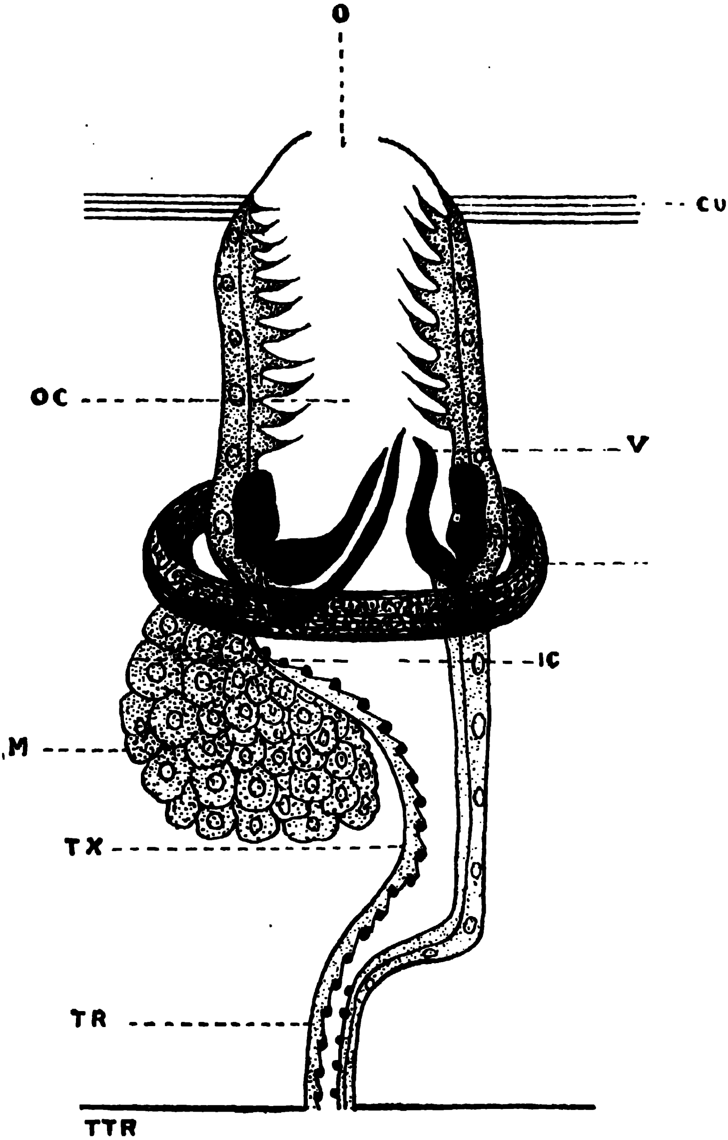


Fig. 2.—Diagrammatic representation of the structure of the mesothoracic spiracle, showing the internal valve, and the closing apparatus. Note the undivided spiracular branch.

o, external aperture of the spiracle; cu, cuticle; c, closing apparatus; v, valve; oc, outer chamber; ic, inner chamber; m, muscle; tx, flexible wall of the inner chamber of the spiracle; tr, spiracular branch; ttr, tracheal trunk.

in the sense that air from tracheae can escape through them, do not pertake in the sound production. The anatomical peculiarity of the first pair gives the answer. The mesothoracic spiracle as will be evident by a reference to the figure 2 is divided into inner and outer chambers which communicate with each other by means of narrow slit guarded by a valve. The valve (fig. 2, v) projects into the cavity of the spiracle and constitutes a part of the closing appartus that encircles like an elastic ring the wall of the spiracle. By the action of the cosing apparatus (fig. 2, c) the slit can be shut or opened. A strong current of air from the tracheal trunk sets into vibration the valve and thus produces sound. The contractibility of the inner chamber seems to help also in producing an outward current. Such a projecting valve or a vibratory membrane, either within the second thoracic or in the terminal abdominal spiracles, is absent; and on account of this and other structural differences previously recorded by me, these spiracles are precluded from emitting any sound. But such an explanation seems untenable in the case of the seven lateral abdominal spiracles (s_3- s_9) which, as shown by me in my paper cited before, are identical in structure to the mesothoracic spiracles in having had the inside valve (fig. 2, v). For the solution of the riddle why the mesothoracic and not these abdominal spiracles act as the organ of voice we should look elsewhere.

There are two main tracheal trunks of large calibre, one on each side, running lengthwise through the body (fig. 3). These trunks posteriorly (i.e. towards the tail end) open directly into the terminal spiracles, thus facilitating the filling up the tracheal trunks with air and carrying on gaseous exchange necessary for respiration (fig. 3, spt.). Each of the lateral spiracles (i.e. the first nine pairs), however, is connected with the main tracheal trunk of the same side, by means of a short trachea of narrow bore (fig. 3). This connecting trachea is spoken of as the spiracular branch (fig. 2). The spiracular branch except in the 1st thoracic and 7th abdominal spiracles soon after its origin from the main trunk gives off two side branches having separate independent destination (fig. 3, bms, bps). As a result of this division of the spiracular branch,

the current of air, on its way from the main tracheal trunk to the spiracle, becomes diverted to some extent along these channels,

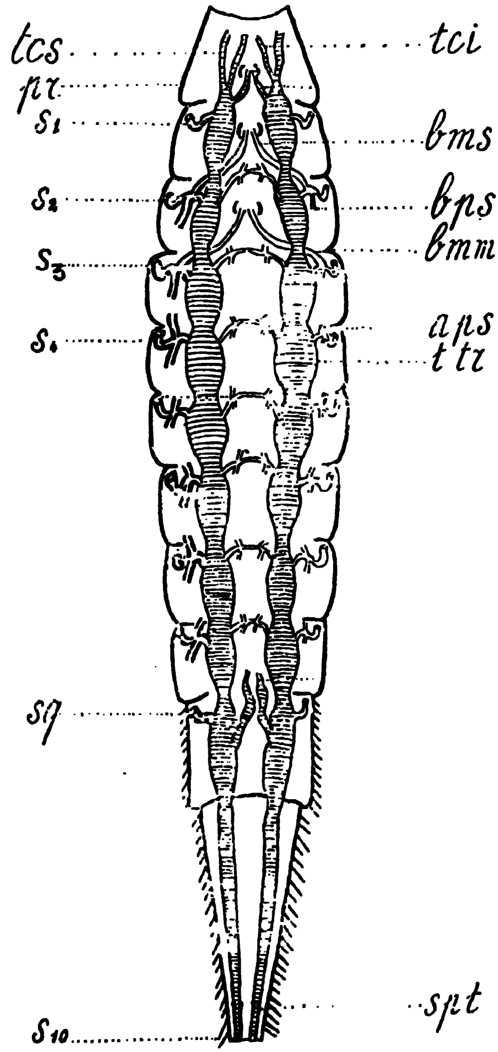


Fig. 3.—Diagram of the respiratory system of the *Cybister* larva, showing the method of connections of spiracles with the tracheal trunk. Note the division of the spiracular branches situated in the middle region of the body.

s_1—s_9, lateral spiracles; s_{10}, terminal spiracles; s_1, spiracular branch of the mesothoracic spiracle; s_3, the first abdominal spiracle; s_9, the seventh abdominal spiracle; ttr, tracheal trunk; bms, bps, side branches of the spiracular branch; spt, posterior limit of the 10th pair of spiracles; tcs, tci, branches of the tracheal trunk supplying the head.

and the pressure of air exerted on the spiracle from inside consequently is too feeble to cause sound by the vibration of the internal valve. On the other hand, the connection of the mesothoracic spiracle (i.e. the first pair of the series) with the tracheal trunk is different. The branch supplying the mesothoracic spiracle goes undivided from the main trunk to the spiracle (s_1 in the figs.). The pressure of air exerted on this spiracle becomes, therefore, sufficiently high to set into vibration the inside valve, and thus to cause sound. This mode of connection curiously enough is also shared by the seventh abdominal spiracle (which is the 9th in the series). But here the pressure, unlike in the mesothoracic spiracle, cannot reach so high and that for a different reason. An undivided spiracular branch is the conduit for the transmission of air to a spiracle, but this itself not having the power of contraction or expansion cannot be the cause of generating high pressure of air contained within a trachea. A bending or squeezing of the body brought about by the activity of the body musculature tells upon the main tracheal trunks and thus forces a strong current of air from the main trunks through the connecting branch to the spiracle concerned and thereby creates a pressure. It has been observed by me that at the time of emitting sound the larva flexes its body in the middle region, so as to cause emission of a strong current of tracheal air through the mesothoracic spiracle, by forcibly driving the air contained in the tracheal trunks forwards and laterally. No such pressure can be exerted on the seventh abdominal spiracle (s_9), as no constriction of the body takes place in the region of the seventh spiracle or the adjacent spiracles. I believe, it is for this reason that the seventh abdominal spiracle, inspite of its resemblance to the first spiracle in structure and mode of spiracular connection, is prevented from emitting a sound. It is also worth noting that the diameter of the tracheal trunk in the middle region of the body is larger than that of the anterior or posterior regions. Further, each of the tracheal trunk in the region of the prothorax, that is, a little ahead of the level of the mesothoracic spiracles, is divided into two long branches with narrow bore (fig. 3, bms, bps). These course forward into the head and subdivide there.

Owing to this arrangement, when the volume of air contained in the tracheal trunks is pressed forward in the direction of the thorax and head by the muscular contraction of the body, considerable resistance is offered to the passage of air through these branches supplying the head, and the current of air, therefore, is forced to flow through the first spiracle where the resistance is comparatively less, the corresponding spiracular branch being short in length. The explanations given above fit in with the facts observable in live specimens kept under water. Bubbles of air issue out in quick succession through the mesothoracic spiracle accompanied by emission of sound, while small vesicles of air are found only adhering to the external rim of other spiracles.

It is clear from the above that the theory of sound production advocated by Landois stands on a firmer basis than admitted by most zoologists, and there could be no doubt about the existence of a true voice in certain insects.

Our knowledge of the insect songsters of India, however, is meagre, and there is a wide scope for investigation along these lines.

The diverse mechanisms by which insect sounds are produced tend to the conclusion that a thing can be done in more than one way.

The Study of Alchemy

By K. C. Viraraghava Iyer (Kumbakonam).

On the festive occasion of his seventieth birthday, I wish to offer my humble felicitations to Sir Prafulla Chandra Ray who, by his devoted work of half a century, has created a school of chemical research in Calcutta and has successfully reared the Bengal Chemical and Pharmaceutical Works and who has latterly directed his beneficent attention to the removal of illiteracy and poverty among the rural population of his province. Furthermore, he has made the chemical world his debtor by the publication of his two volumes of "The History of Hindu Chemistry." He had patiently searched many an old sanskrit manuscript or nuggets of alchemical lore and had woven a splendid texture wherein he has proved that alchemy in India had an independent existence and growth and the knowledge of the Hindus of those days in technical arts and chemical manipulations suffered in no way from a comparison with the similar knowledge that existed at the time in other parts of the world. Eminently a Doctor of Nitrites, he sometimes used to call himself as a Doctor of Doctors in the presence of his Doctor students who are really large in number and who have carried his inspiration to all parts of India. Such an eminent Indian scientist deserves all possible recognition and congratulation from his old pupils and admirers on his seventieth birthday. May he live long to see his country getting more and more famous in the scientific world of the day!

In his admirable History of Hindu Chemistry he has naturally restricted his attention to the available sanskrit manuscripts and has traced the growth of alchemical and chemical ideas as revealed in them from century to century. He had worked hard at this for more than fifteen years and the publication is nearly quarter of

a century old. I wish to serve him, at his seventieth birthday feast, a tiny dish of alchemy as is found in the extreme south of India; for in the extreme south of India there exists a language, Tamil, which has always claimed an independent origin and growth and has to its credit a hoary literature of ancient times and has survived the onslaughts of many foreign languages with a possibility of absorbing many of these tongues in its fold and thus proving its virility; and in that language is found a considerable body of literature devoted to Alchemy, Alchemy and Yoga, Alchemy and Medicine, much of which has been published and more yet remains to be published. These are not referred to in his book by Sir P. C. Ray for obvious reasons, and I desire now to present a bare outline of the alchemical works in Tamil.

There is still a necessity for the study of alchemical works in all languages; for alchemists are present with us even in the twentieth century and Alchemy has been the direct ancestor of Chemistry. As E. J. Holmyard observes, a great deal of work remains yet to be done if we wish to get a clear picture of the development of chemical thought throughout the ages. In his opinion even the eighteenth century literature has been insufficiently studied and the previous centuries get hazy. The first step to rectify this unsatisfactory state of affairs is an investigation and classification of all materials in all languages at our disposal. Greek and Latin manuscripts have been critically studied for a long time and recently Arabic and Chinese manuscripts are being scrutinised at the places of their origin. A comparative study of the chemical thought contained in these writings is attempted by eminent chemists of the present day.

It was a pet theory of many European scholars that all knowledge came ultimately from Greek and Roman sources. In recent times they have cast their eyes further east and are discovering the possibility that many departments of knowledge might have originated in Arabia, Persia, India and China. M. Berthelot considered that Chinese Alchemy was derived from the Arabs, and Lippmann elaborated it by saying that it was introduced by the

Arabs into China towards the beginning of the ninth century A.D. J. R. Partington is of the opinion that an Indian or Chinese origin is possible for even Arabic Alchemy in the tenth century. O. S. Johnson regards Chinese Alchemy as an indigenous growth arising from the system of Taoism. But Laufer and Lippmann agree that Alchemy was an entirely foreign element in Chinese thought and Laufer has attempted to prove that it reached China from India in the third century A.D. or even earlier. All these changes of view among scholars show that there is thirst for fresh material so as to clarify the confounded and illfound guesses of early writers. Sir P. C. Ray has abundantly shown that Alchemy in India was closely associated with the Hindu and Buddhistic tantras of the early centuries and that, during the downfall of Buddhism in India, the Buddhist scholars carried their knowledge to Tibet, China and other places, and even translated their old writings into the languages of the places where they took shelter. Evidence is fast accumulating to show that there has been a constant intercourse among the early civilised inhabitants of China, India, and the Mediterranean countries. South India seems to have been particularly favourable for the easy intermingling of such people by sea and we have got the impress of their stay recorded in some of the known literature of the land.

After an elaborate discussion about the fusion of the Hindu tantraic cult with that of Buddhism from the second century A.D. onwards, Sir P. C. Ray has constructed a superb niche for Nagārjuna, who inaugurated the blend of the two tantraic cults with which Alchemy in India had a close association. Barth has said that "The obscenities of the Saivite Tantras have deeply infected the Buddhist Tantras of Nepal and through them the Tibetian translations, the majority of which are of a date prior to the ninth century." He further says, "Far purer is the form in which Civaism appears in the Tamil Poetical effusions of the Sittars (in Sanskrit Siddhas) 'perfect ones.' We know but little of the sect from which these compositions emanate; at the present day it appears to be extinct; but hymns themselves have retained their popularity, notwithstanding the peremptory way in which

they denounce the most cherished beliefs of the masses. They are compositions, in general, of no great age going back not more than two or three centuries, although they circulate under the names of the famous saints of antiquity, such as Agastya the fabled civiliser of the Dekkan and his not less fabulous disciples. In elevation of style they rival the most perfect compositions which have been left us by *Tiruvalluvar, Auveiyār,* and the ancient Tamil Poets." Furthermore "in regard to Alchemy, anyhow, in which the Sittars are zealous adepts, they were disciples of the Arabians, although other Civaites had preceded them in pursuit of the Philosopher's stone." Barth smells the influence of the Arabians in the "severe monotheism of the Sittars." Barth wrote these words in 1881 and depended for his conclusions mainly on the guesses made by Caldwell in the second edition of his 'Comparative Grammar of the Dravidian Languages,' published in 1875; much water has flowed under the bridge since then and the wise authors of the third edition of the Caldwell's Grammar (published in 1913) had omitted all the debatable and worn-out speculations of Caldwell among which the reference to Sittars is one. In consequence much of Barth's arguments falls to the ground.

Tamil works allude to eighteen Sittars proverbially while Rasa Ratna Samuchhaya mentions 27 experts on Alchemy and Sir P. C. Ray gives the names of many others. In Tamil a few Sittars are grouped together as Nava Nātha Sittars. Most of them have been religious reformers of their day and have no doubt used their hatayoga powers for the purpose. Especially their lives and works are said to be found in some authentic Marathi literature of the XIII century and their pedigree is given as follows by Pandit Panduranga Sarma, Poona (vide III Oriental Conference Proceedings 1924, page 495):—Ādinātha, Matsyendranātha, Nivirthinātha, and Jnananātha (1275-1296). But mention is made, in Tamil works, about Ādinātha, Anādinātha, Satyanātha, Sathokanātha, Vahulinātha, Matanganātha, Matsyimdranātha, Gatendranātha alias Vilaiyattu Sittar, Gorakshanāthar. Their chronology will be an interesting study.

Bhudeb Mukerji M.A. in his article on "Indian Chemistry

and its Antiquity'' (1928) has elaborately dealt with the names of the 27 experts found in Rasa Ratna Samuchhaya. He identifies the Indian Adimma the Sittha, with the Sabian Adimum the Snith (Cf. Stapleton), places Chandrasena about 5000 B.C. and credits Ravana and Sri Rama with alchemical works: Sāmbhu's Rasārnava, Nagārjuna's Rasaratnākara, and Govinda's Rasa Hridhya and Rasa Sāra are the only ones definitely known; while nothing is known yet about the twenty-one others. On the other hand some of the works of all the eighteen Sittars mentioned in Tamil have already been published and many more remain yet to be published. This is neither the place nor the time to give a detailed review of the published works but I shall attempt to give a few characteristics of the works of Tamil Sittars:—

(1) The works of the Sittars deal either with alchemy by itself, alchemy and yoga, alchemy and medicine or medicine pure and simple.

(2) They are called after the names of the authors or the names of the author's gurus.

(3) Most of them are written in verse, using easy colloquial and ungrammatical words and often hiding the names of the herbals or minerals in big phrases and metaphors.

(4) Many Sittars have the common characteristic of first writing long poems and then condensing them into shorter ones successively. For example Satta Muni is credited with having written a work of 2,50,000 stanzas, and then condensing them into Satta Muni Vāda Kāvya of 2,500 and 1,000 stanzas and then into Satta Muni Karpa Vidhi of 100, and again into Satta Muni Sutra of 25 or 10 stanzas.

(5) No diagrammatic sketches have been found so far in any of the manuscripts; but some may be easily constructed from the detailed instructions given for the apparatus and processes.

(6) There are no commentaries on these works but there are many *nigantus* or lexicons which give the names of herbals and minerals which are synonymous.

(7) References to kings are not found in any of the works

of the Sittars, so far as is known. Such references will be very useful in fixing the dates of these Sittars.

(8) They recognise Siva for their God and reject everything in the Saiva System which is inconsistent with pure theism.

(9) Many receipes containing minerals, metals, herbals, and salts are mentioned.

(10) As usual the Tamil Alchemy is associated with magic, exorcisms and propitiations.

Agastya is foremost among the Tamil Sittars. His name is not mentioned in Sir P. C. Ray's books or Bhudeb Mukerji's book. Modern research is converging towards the view that there have been two Agastyas, one, the renowned Aryan coloniser of the south and the other, the famous Tamil grammarian and prolific writer in Tamil. Caldwell wrote "We shall not greatly err in placing the era of Agastya or that of the commencement of Tamilian civilisation and literature in the seventh or at least in the sixth century B.C." This opinion is getting more than confirmed. Most of the alchemical works that go by the name of Agastya are not considered to be genuine. "Plato, Democritus and Geber have been held responsible for writings which appeared several centuries later. Names, venerable and illustrious, have been pressed into service to lend weight and dignity to productions which otherwise would not have commanded a respectful hearing." So also in Tamil. In a work called "Patanjali Gnānam Fifty-four," one verse classifies Agastya's works as follows:—

1. Nigantu ten thousand.
2. Kāvya one thousand.
3. The big Veda 1,250, 16, 80 and 500.
4. Pari Bhāshai 2,11,000,600.
5. Pūranam 7,00, 600, 200 and 31.
6. Ocean 7,000.
7. Hema Tatvam 800 and 400.
8. Salt 100.
9. Siva yogam 100.
10. Knowledge 100.

(the numbers refer to the number of verses in each book)

The eighteen Sittars are mentioned by Sundrānandar in his "Rules of Dikshai 50" as follows :—

1. Agastya.
2. Tirumūlar.
3. Bogar.
4. Konganar.
5. Sattainathar.
6. Macha Muni.
7. Karuvūrar.
8. Idai Kāttar.
9. Punnākkisar.
10. Kamala Devar.
11. Gorakkar.
12. Nandīsar.
13. Rāma Devar.
14. Brahma Muni.
15. Vasa Muni.
16. Azhu Kanni.
17. Roma Muni.
18. Sundrānandar.

Another verse in the "Patanjali Gnānam" (page 541) mentions that the Sittars works can be classified as follows :—

1.	Tirumūla Mandiram	8,000
2.	Bogar	7,000
3.	Konkanar	5,000
4.	Satta Muni ...	1,200 and 1,000
5.	Sundarar	1,000
6.	Macha Muni	800

And the verse further says that Kapila, Janka, Namdi and Roma Muni wrote in sanskrit many alchemical works. A close study of all these works is required before any decision could be pronounced on their chronology, authenticity and contents.

Bogar is a prolific writer of alchemical and medical works in Tamil. He is said to be a Chinese who came to India in the III century A.D. and visited Patna and Gaya and then South India and learned alchemy and medicine from Tamil savants. He

taught the Tamils also in these lores. There is not much of Buddhism found in his works. He is said to have visited Arabia and then gone to his native land. It appears that some Tamil disciples accompanied him to China and after learning some mechanical arts, they returned to Tamil Nad and won some laurels.

Pulipāni was another Chinaman who came along with Bogar but he chose to settle in the Tamil territory. He has also written many Tamil works on Magic, Alchemy and Medicine.

Teraiyar is reputed to have been a clever surgeon. He removed a toad from the cerebrum of a nobleman and cured his headache. He takes his name after this operation. (The Toad-Man). He was a disciple of Agastya. A similar incident is said to be found in the Sanskrit Bhoja Prabandham.

Sattainathar is referred to as Kamblisattanathar Muni. There is reference to Kambli in the 27 names mentioned in Rasa Ratna Samuchhaya. Probably some of Kambli's sanskrit works are to be found in Tamil translations just as some Buddhist sanskrit works were found in Tibetan translations.

Many of the Sittars are found to rebel against the strictly monistic philosophy of Sankara and the idolatrous worship of the Hindus. Probably they may be assigned to a period, X to XV century A.D. A systematic account of these Sittars and their works will be published later elsewhere.

Dr. P. C. Ray: The Dedicated Life

By **S. K. Maitra** (Benares).

On the occasion of his seventieth birthday, I offer my humble felicitations to that living incarnation of Sacrifice, Dr. P. C. Ray. His has been a dedicated life in the truest sense of the word. The motto of his life is Service. Whether in the cause of science or in the cause of his country, he has shown a devotion which is absolutely without a parallel. And the great feature of his service has been its total selflessness. If there is any man who has made selfless service his religion, it is Dr. P. C. Ray.

To glaring simplicity and sacrifice, Dr. P. C. Ray has joined wonderful practical insight and business acumen. The combination is probably unique in the history of our country. The Bengal Chemical and Pharmaceutical Works are a lasting monument of his business enterprise and practical knowledge.

Dr. P. C. Ray is an ideal teacher. His relations with his pupils remind one of the best traditions of गुरुशिष्य-relationship in ancient India. It would not be an exaggeration to say that he lives for his pupils. No teacher in recent times has trained so many worthy young men and no teacher is so proud of the achievements of his pupils. One incident I shall never forget. It occurred at the Bengali Literary Conference at Meerut in 1929. At the close of his address, he said, pointing to one of the most brilliant of his pupils—Dr. N. R. Dhar—and with tears rolling down his cheeks, "I can say of them what the mother of the Gracchus brothers said of her sons,—These are all that I possess; I have no other assets."

How can we pay homage to such a man? Our best homage to him is to accept his religion, the religion of selfless service. All who have come in intimate contact with him have imbibed his cult

of selfless sacrifice. If we want to show respect to him, we should join his band of selfless workers.

Our country is particularly fortunate at this moment, for she possesses an incomparable leader, a great prophet and a wonderful worker. In Gandhi, Tagore and P. C. Ray, she possesses all the three elements essential to success in her great struggle for freedom and self-determination—great leadership, a noble vision and selfless devotion. May she long enjoy the services of these three great sons of hers!

On the Life History of *Rhacophorus maximus* Gunther[1]

By Jnanendra Lal Bhaduri (Calcutta).

(Plate XVI).

In the course of my investigation on the ecology of the tadpoles found in the streams round Dumpep in the Khasi Hills, Assam, during the month of May, 1930, I came across a frothy egg-mass of a tree-frog of the genus *Rhacophorus* in a small puddle at Cherrapunji. It was quite fresh and appeared to have been laid early that morning. The whole frothy egg-mass was colletced in a large vessel and was kept under constant observation, with daily changes of stream water, till it was brought down to Calcutta three days later. During the journey from Shillong to Calcutta all the eggs hatched out.[2] The larvae were kept in an aquarium in the Indian Museum, the water of which was changed every day from the Museum tank. They were fed on chopped goat's liver till they metamorphosed in about two months' time. Great difficulties were experienced in keeping alive the tadpoles that were in process of metamorphosis, as also those that had metamorphosed, but I succeeded in rearing up to completely metamorphosed frogs only a very limited number. A fair series of specimens from the egg stage to fully transformed frogs were preserved for study.

Even with this complete series of material I found it very difficult to identify the species of frog to which the tadpoles belonged. This was due to no adult frog having been found in association

1 Published with the permission of the Director, Zoological Survey of India, Indian Museum, Calcutta.

2 The time taken for hatching was perhaps much shorter than what would actually occur in nature. This was presumably due to great vibration and jolting of the Bus plying from Shillong to Pandu Ghat.

with the frothy egg-mass. Following, however, the method of elimination and taking the range of distribution of the different species of *Rhacophorus* into consideration, I provisionally assigned the metamorphosed frogs to *Rh. bimaculatus* Boulenger.[3] But from an examination of a complete developmental series of this material presented to the British Museum, London, Dr. Malcolm A. Smith has identified the frog as *Rh. maximus* and has remarked that "the complete absence of any fringe to the limbs in your metamorphosed frogs makes it quite certain that it is not *bimaculatus*."[4]

Rh. maximus is commonly found in the Khasi Hills, but so far no tadpole or any frothy egg-mass[5] of this species has been described. There are, however, in the reserve collections of the Zoological Survey of India, tadpoles from the Darjiling District that have been referred to this species, but these on examination are found to agree more closely with those of *Rh. bimaculatus*[6] than with those of my series from Cherrapunji.

In this paper I propose to describe briefly the developmental series preserved by me, and, finally, to give a detailed systematic description of the tadpole.

I have here to record my sincere thanks to Lt.-Col. R. B. Seymour Sewell and Dr. Baini Prashad for kindly reading through my manuscript and to Mr. A. C. Chowdhury for the figures in the accompanying plate which he has drawn with his usual skill.

Development of the tadpole

The eggs are yellowish white, single, not adhering to one another and scattered irregularly in the frothy mass. They are unpigmented and are about 2 mm. each in diameter. With the development of the eggs the capsules grow in size, and on the third day the larvae are hatched as mentioned before. The hatched out

3 *Rh. bimaculatus* Blgr.=*Rh.* (*Rh.*) *bipunctatus* Ahl (*vide*, Ahl, E.—Polypedatidae, Anura III, *Das Tierreich*, Lief. 55, p. 168, 1931).

4 My sincere thanks are due to Dr. Smith for the identification.

5 Bhaduri, J. L.—*Anat. Anz.*, LXXIV, p. 337, (*Footnote*) 1932.

6 Smith, M. A.—*Bull. Raffles Mus.*, Singapore, No. 3, p. 115, 1930.

larvae stick to objects under water by means of their adhesive apparatus.

The adhesive apparatus (= 'cement organs' or 'Haftapparat' of authors) which characterises the batrachian larvae in the early stages of their life, begins to develop while they are still within the capsule. By the time the larva is ready to hatch out, the adhesive aparatus is found to consist of two rounded swellings situated close together and posterior to the stomodaeal pit (Fig. 1). Soon after hatching the adhesive apparatus reaches its maximum development and appears as two very prominent rounded unpigmented structures situated laterally and slightly posterior to the developing mouth (Fig. 2). It produces a secretion that helps the larvae to adhere to objects under water.[7] The adhesive apparatus, however, functions for a short time and becomes atrophied early in the nascent tadpole life.

The average total length of the newly hatched larvae is about 10 mm. The colour of these larvae is yellowish white, finely stippled or suffused with black pigments on the dorsal parts of the head and body and partially on the tail. As the larvae grow older the pigment becomes denser. Approximately three days after hatching the colour pattern becomes well established and persists without change even in the newly transformed frogs. Living tadpoles and metamorphosing frogs, when seen with the naked eye, are of a uniformly shining lead-blue colour above and almost white below; on examination under a binocular microscope, however, sparsely distributed pigment cells are also to be seen on the ventral parts.

The gills begin to develop, while the larva is within the capsule, as two buds on either side (Fig. 1), later finger-like processes are developed from these buds and as soon as the larva hatches out the processes assume the normal gill-like appearance (Figs. 2 and 3). The finger-like branches of the gills are fairly numerous and the longest ramus averages 2 mm. in length. No pigment was observed on the gills. As development proceeds the

7 Thiele, J.—*Zeit. wiss. Zool.*, XLVI, pp. 67-69, 1887.

operculum grows over the external gills from the right to the left leaving the spiracular aperture on the latter side. The spiracle is directed backwards and upwards.

It may be mentioned in this connection that within a few days after hatching the tadpoles begin to resort to double respiration, for, it was observed that they came to the surface of the water to breathe air directly from time to time, in spite of the fact that they had well developed and functional internal gills for aquatic respiration.

The mouth followed the usual course of development and assumed the mature tadpole pattern in or about the 20 mm. stage. It will be described later on.

The buds of the hind limbs were first observed on either side of the vent in tadpoles of about 20 mm. total length. These buds grow and appear as oval unpigmented structures in the 27 mm. stage. Finger-like processes on the buds were observed in a tadpole of about 35 mm. stage. The hind-limbs assume their adult character in tadpoles of about 44 mm. long. The toes are more than half webbed. The fore-limbs, which grow under the ventral body wall, appear later in the life of the tadpole. The left limb breaks through first, presumably through the spiracle (Fig. 6), and the right limb emerges a day or two after. The fingers are moderately webbed. I have observed paired crescentic openings with slightly thickened lips, immediately in front of the bases of the freed limbs. The function of these as the exit passages of the branchial current was first observed by Latter,[8] and later confirmed by Brock.[9]

In moderate sized tadpoles a series of finely pitted sense organs are present on the dorsal surface of the head and body (Fig. 5). The anterior series begins from the snout and extends in two rows over the nostril and the eyes. The posterior series likewise begins as two rows behind the eyes and passes backwards to disappear in the upper mebrane of the tail. It should, however,

8 Latter, O. H.—'*Nature*'. CXI, Febr. 3, p. 151, 1923.

9 Brock, G. T.—*Quart. Journ. Micros. Sci.*, LXXIII, p. 341, 1929.

be noted that this series of sensory pits begins to disappear in the later tadpole stages, and is entirely absent in the metamorphosed frogs.

The 'parietal fleck' which characterises many tadpoles and frogs, is well represented in the series of tadpoles from Cherrapunji (Figs. 5, 6 and 7). It appears as a little whitish spot on the centre of the head between the eyes. It is a charcteristic feature throughout the tadpole stage and even persists in the newly transformed frogs.

Habits of the tadpole

Larvae raised in the aquarium did not seem to be active swimmers. Most of the time they were found to be resting on the bottom or in the weeds of the aquarium. When alarmed they used to seek concealment by diving under masses of weeds. Their respiratory habits have already been mentioned above.

When chopped goat's liver was offered, held in a thread, they used to approach it quickly and without fail. They ate it with much avidity practically everyday. They had no aversion to any of their companion that died and invariably skeletonized it within the course of a day.

Description of the tadpole

(Figs. 4, 5 and 8)

Head and body. Length one and half times the width, broadly oval in outline; abdomen slightly convex; throat somewhat flattened; snout rounded.

Nostrils. Small, rather widely separated, on the upper surface of the head, a little nearer the eyes than the tip of the snout.

Eyes. Superolateral, not prominent, the interocular space a little greater than that between the nostrils and also greater than the width of the mouth.

Mouth. Subterminal, small and distinctly transverse, its greatest width greater than the internarial width. Lower lip

bordered by two or three rows of minute blunt finger-like papillae and continuous with the lateral emarginations, which are also similarly fringed; upper lip is distinct and without any such papillae. Four series of teeth in the upper lip, the first continuous, the remaining three successively shorter and broadly interrputed in the middle. Lower lip with three long series of teeth, the first row slightly shorter and barely interrupted in the middle, the remaining two continuous and about equal in length. *Dental formula*:—1 :3 + 3/1 + 1 :2. Beaks edged with black and very finely serrated. Upper beak wide and broadly crescentic, the middle part being almost straight; the lower one broadly V-shaped.

Spiracle. Sinistral, small, pointing backwards and upwards, plainly visible from below, scarcely seen from above, its opening nearer the vent than the end of the snout.

Anus. Dextral, opening under a fold of skin which is continuous with the subcaudal crest.

Tail. Moderately long, with rounded tip, about four times as long as deep and more than one and half times the length of the body; its maximum depth almost equal to the greatest depth of the body; upper crest about the same depth as the lower one, not extending on to the back. Muscular portion well developed.

Toes. More than half webbed. Fingers also webbed (Figs. 6 and 7).

Sense organs. A series of finely pitted sense organs symmetrically disposed on the dorsal surface of the head and body. The 'parietal fleck' situated mesially on the head between the eyes.

Glands. Apparently none.

Colour. Uniform, shining lead-blue above; ventral parts dirty white; membranes of the tail slightly paler, immaculate; the muscular part of the tail brownish.

Dimensions in millimetres.

SPECIMENS		A.	B.	C.	D.	E.
Total length	...	15·5	23	37	42	47 (maximum)
Length of head and body	...	6	9	14	16	16
Breadth of head and body	...	4	6	8·1	10	10·1
Greatest depth of tail	...	4	4·9	6	8	8·1

EXPLANATION OF PLATE XVI.

Rhacophorus maximus Gunther, from Cherrapunji, Khasi Hills, Assam.

Fig. 1.—Larva taken out of the capsule showing the adhesive apparatus: ventral aspect, × 8.

Fig. 2.—Larva just hatched out showing the adhesive apparatus and the gills: ventral aspect, × 10.

Fig. 3.—Same as above: lateral aspect, × 10⅔.

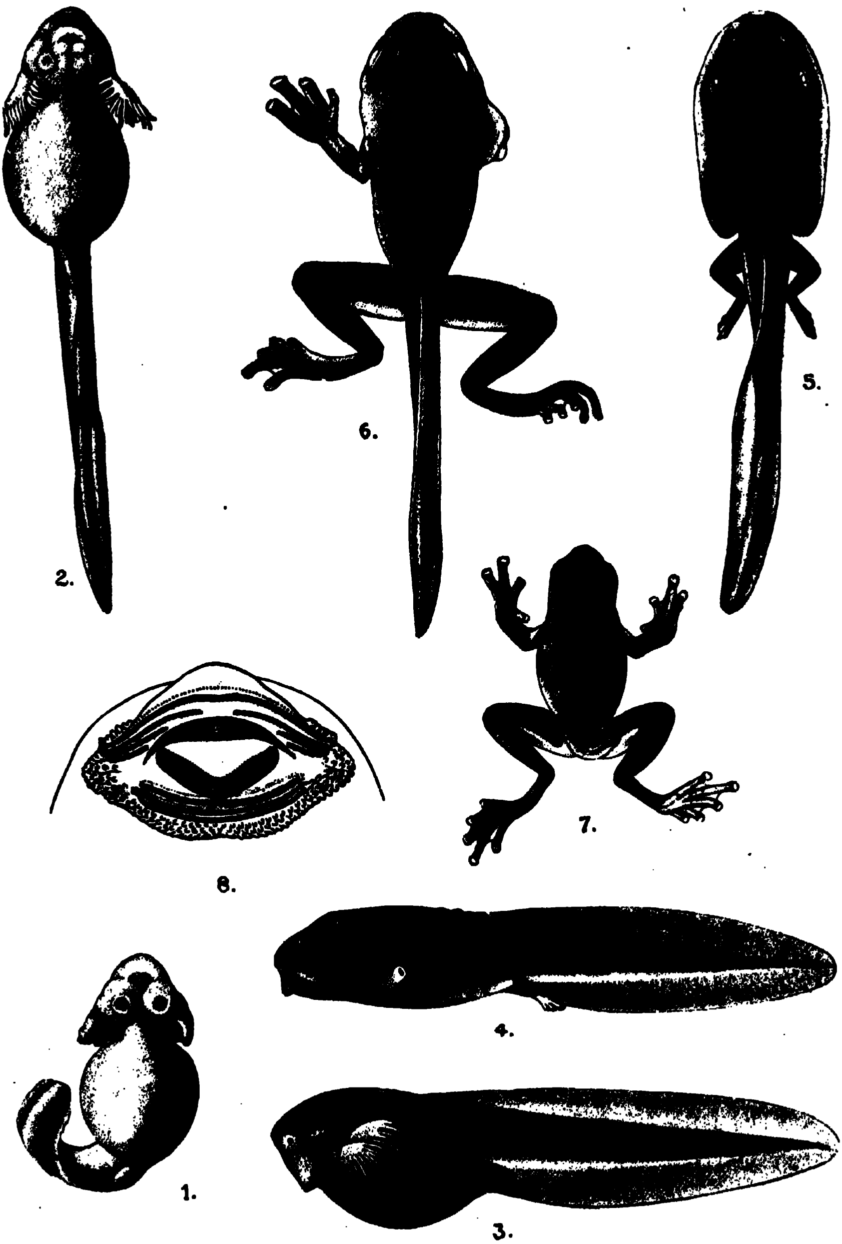
Fig. 4.—Mature tadpole, showing the characteristic pattern: lateral aspect, × 1.

Fig. 5.—Mature tadpole, showing the pitted sense organs and the "parietal fleck": dorsal aspect, × 1.

Fig. 6.—Mature tadpole: dorsal aspect, × 2⅓.

Fig. 7.—Almost completely metamorphosed frog: dorsal aspect, × 1.

Fig. 8.—Mouth disc of the tadpole, × 12.



A. Chowdhury *del.*

The Indian Photo Engraving Co., Cal.

Observations on the stone-licking fishes of the genus *Garra**

By Dev Dev Mukerji (Calcutta).

Among the Cyprinoid fishes of the Indian hill-streams there are few that can surpass the members of the genus *Garra* in the matter of familiarity,[1] abundance, wide distribution and interest from the evolutionary point of view. The outstanding characteristic of the Garras is the possession of a more or less well-developed suctorial disc on the undersurface situated just behind the mouth. Most of the fishes of the genus, which are numerous in the hilly districts of the Indian Empire and elsewhere, inhabit rapid-running waters and protect themselves against swift currents by clinging tight to the substratum mainly by means of their suctorial disc, and partly by the horizontally placed paired fins, specially the pectorals, the outermost rays of which are provided with adhesive pads in some highly specialised species. In similar manner, certain Garras have also been known to climb vertical surfaces of wet rocks behind water-falls.

The first species of the remarkable genus *Garra* was discovered well over a century ago from the Bhagalpur and the Gorakhpur Districts, and was described as *Garra lamta* by Francis Hamilton (once Buchanan), the famous author of the "Accounts of the fishes of the Ganges" (1822). Since then Garras have attracted

* Published with the permission of the Director, Zoological Survey of India, Indian Museum, Calcutta.

1 The wide popularity of the fish is clearly indicated from the fact that in almost every district of India and Burma it is known by certain vernacular names, such as *Pathar-chata*, which refer to the characteristic stone-clinging and stone-licking habit of the fish (*vide* Hora, S. L.—"On certain local names of the fishes of the genus *Garra*" *Journ. & Proc. Asiat. Soc. Bengal,* (N. S.), XIX, pp. 105-109, 1923).

the attention of most of the later ichthyologists whose observations on the bionomics of these fishes have considerably advanced our knowledge. Unfortunately, till recently, the taxonomy of the whole group was in a state of confusion, and the greatest confusion centred round the historic species, *G. lamta*, which was used as a lumber-room for several closely allied forms. However, the works of the modern authors, specially those of Annandale[2] and Hora,[3] have sufficiently cleared up and stabilized the taxonomy of *Garra*, and though certain aspects of the ecology, bionomics and the probable evolution of these specialised hill-stream forms have been illumined by these authors, others yet remain to be elucidated. In the following pages I propose to record briefly my observations on *G. gotyla* (Gray) and *G. annandalei* Hora with special reference to the deeper side pools and their behaviour therein.

Towards the end of March, 1932, I was making a representative collection of the fishes of the Sevoke stream in the Teesta Valley at the foot of the Darjiling Himalayas. The portion of the stream surveyed lay between its fall into the Teesta River near Sevoke railway station, and a bend about a mile or so up the course. At that time of the year the stream followed a narrow, zig-zag, and very shallow course, flowing feebly over the pebbly bed which was for the most part exposed. Here and there, in the bed of the stream were a few side pools and ditches of moderate depth, and with a bottom of stones, sand, clay, silt and débris. During the rainy months these pools become overflowed and form part of the Sevoke stream which then takes the form of a torrential rivulet, while in the dry season, as at the time of my visit, the pools are either just connected with or entirely cut off from the main stream. The water of these pools was remarkably clear, and it was, therefore, possible to watch the animals of the bottom, almost as if they were in an aquarium.

2 Annandale, N.—"Notes on fishes of the genus *Discognathus* from India and Persia" *Rec. Ind. Mus.*, XVIII, pp. 65-78, pls. ix-xi, 1919.

3 Hora, S. L.—"Indian Cyprinoid fishes belonging to the genus *Garra* with notes on related species from other countries" *Rec. Ind Mus.* XXII, pp. 633-687, pls. xxiv-xxvi, 1921.

As one would naturally expect, the fish-fauna of the pools consisted of such forms as are adapted to live both in the streams and the associated pools, and select one habitat when the other becomes unfavourable either for life or for breeding. Among the fishes of the pools were to be found large numbers of *G. gotyla* (Gray) and *G. annandalei* Hora, which, though essentially stream forms, had migrated to the adjacent deeper pools to evade the difficulties of life in the drying stream. From the shallow pebbly bed of the stream itself I captured, in addition to other small and slender fishes, such as, *Laguvia shawi* Hora, *Amblyceps mangois* (Ham. Buch.) and *Olyra kempi* Chaudhuri etc., large numbers of young specimens of the aforesaid species of *Garra*. It is curious that the adult Garras were extremely rare in the stream, while they were plentiful in the pools. This shows that the extreme scarcity of water in the stream is suitable for the slender young forms only, while for the adult individuals the stream becomes temporarily unfavourable, inasmuch as they are likely to be much "out of water" there and hence in constant danger of desiccation or of being preyed upon by many of their natural enemies. From the standpoint of shelter, therefore, we find that, while the adult Garras must, of necessity, temporarily migrate from the drying stream to the adjacent pools, similar migration of the juvenile forms is hardly necessary. Food is yet another important factor that should also be here considered. The comparative paucity of food material in the limited body of water of the isolated pools renders them unsuitable for the young forms which need a proportionately greater amount of food for nourishment and growth than that which is imperative for the adult individuals. The stream-dwelling Garras in their immature stages are thus not subjected to any special disadvantages during the dry season, and they can, therefore, maintain themselves more easily in a partially drying stream than in deeper pools, while adults can with difficulty survive only by fleeing to a retreat like the deeper pools and ditches.

The migrant Garras, as observed in the isolated pools, are not very active or agile, which may be partly correlated with their being in a medium where the amount of available oxygen is comparative-

ly less than it is in the running stream water. The fishes apply their chest and the paired fins, specially the pectorals to the bottom of the pools and rest there quietly. In fact, they seldom move at all and seem to enjoy a characteristic idleness. They are invariably found in groups and disperse only when disturbed by the splashing of water or dropping of a stone in their midst. When disturbed they dart about for some time, but eventually form a group again. This phenomenon should not, however, be mistaken for the permanent schooling habit of certain fishes.[4] It is a sort of natural reflex of the fishes coming to dwell in a new habitat. In marked contrast with different species of *Barbus*, *Barilius* and *Danio* etc. of the pools, the species of *Garra* swim, when they do, rather slowly and somewhat awkwardly with occasional darting movements, keeping their bodies more or less horizontal and in close proximity to the bottom. At a stretch they do not go very far, nor swim round about but invariably in a straight direction, and over a short space. This characteristic mode of swimming of the migrant Garras in the pools seem to indicate similar habits of the fish in the streams, where it normally progresses by short leaps from rock to rock, straight ahead and against the current; and as the fish must choose the path of the least resistance, it always keeps at a lower stratum of the current and hence close to the bottom where the velocity is lesser.[5]

It is but natural that the habits of the still-water dwelling primitive or degenerate forms of Garras should be quite different from those of the temporary migrants from the stream under consideration. Primitive forms like *G. adiscus* (Annandale) and *G. mullay* (Sykes), which are believed to have started their progressive differentiation for stream life comparatively recently, are only a little more advanced and specialised, both in respect of their morphology and habits, than the *Crossochilus*-like ancestral form of the calm

4 Parr, A. E.—"A contribution to the theoretical analysis of the schooling behavior of fishes." *Occ. Papers Bingham Oceanographic Collection*, I, pp. 1-32, 1927.

5 Hora, S. L.—"Ecology, Bionomics and Evolution of torrential fauna with special reference to organs of attachment." *Phil. Trans. Roy. Soc. London*, (B) CCXVIII, p. 175, 1930.

waters. Their behaviour and mode of life are, therefore, likely to correspond more to those of the typical dwellers of the still-waters than to those of their highly specialised congeners of the mountain rapids. In the course of constant adjustments to the varying conditions of life, however, both the groups of Garras may at times be found in a similar habitat as for example, a pool or a lake. In a body of still-water, like pools, lakes and ditches in the vicinity of mountainous streams, may be found three distinct bionomic groups of Garras. To the first group belong the primitive forms like *G. adiscus* (Annandale) and *G. mullay* (Sykes) while to the second, such degenerate species as *G. gravelyi* (Annandale) and *G. rufus* (Heckel). The third and the last group is represented by temporary migrants from the streams such as *G. gotyla* (Gray) and *G. annandalei* Hora. Plainly enough, although the three dissimilar bionomic groups of Garras may be undergoing processes of physiological adaptability in more or less a similar *milieu*, the processes proceed along different paths and lead to different goals, *viz.* (i) progressive adaptation towards stream life, (ii) retrogressive degeneration from stream life and (iii) temporary migration from streams to still-water.

Each habitat offers definite advantages and disadvantages, and when animals migrate from their normal home to some other environment, for some purpose or other, they have to make many adjustments between new advantages and disadvantages, old necessities and new requirements, and old habits and new abilities. The foregoing account of the two species of *Garra* illustrates this view to some extent. Annandale's observations[6] on the post-clmbing and feeding habits of *G. gravelyi* of the Inlé Lake in the Southern Shan States in Burma are also relevant to the point. The post-climbing habit by means of its suctorial disc and paired fins of this degenerate lake form, as also its mode of feeding by scraping algae and other organic matters from off the submerged posts, are certainly manifestations of the *old habits* of the past stream life

6 Annandale, N.—"Fish and fisheries of the Inlé Lake." *Rec. Ind. Mus.*, XIV, p. 45, 1918.

of the fish. Again, the peculiar mode of seizing food, not lying at the bottom, the act of nibbling at the bones of chickens and pigeons, thrown into the water, and feeding on the dead of their own kind in the case of *G. rufus* (Heckel) of the Lake Tiberias in Syria,[7] seem to indicate certain *new requirements*, and the development of *new abilities* in order to satisfy them.

7 Annandale, N.—"Notes on fishes, Batrachia and Reptiles of the Lake of Tiberias." *Journ. & Proc. Asiat. Soc. Bengal*, (N. S.), IX, p. 37, 1913.

Time in Ancient, Mediaeval and Modern Chronology

By Sukumar Ranjan Das (Calcutta).

Long before the physical and philosophical notion of Time was developed, it was found necessary to have a standard measurement of Time for all practical purposes—religious as well as secular. There arose in all the ecclesiastical schools of the ancient nations the necessity for instructing some member or group of the priestly order in the process of computing the dates of the religious festivities.[1] The problem was universal and was not confined to any particular religious sect. Since most early religions were connected with sun worship or with astrology, work somewhat similar to that of preparing the computus was needed in all religious organizations—Hindu, Greek, Egyptian, Chinese, Babylonian, Hebrew, Mahammadan and ancient Roman.[2] Among all the nations, the fundamental periods of Time, the day, the month, the year are the same, the variations occurring in them being principally in the arrangement of the days to form months and years; in the subdivisions of the day; in the times to be reckoned as the commencement of the day, whether at mid-night, sunrise, or noon; in the subdivisions of the year into months, differing from each other as to the number of days of each; in the various kinds of months to form the year, and the like. There have been in all nations certain difficulties experienced as to the time when the year should be reckoned to begin, and in the consequent arrangement of the months and seasons, so that they should recur at regular intervals.

1 The Discovery of Time by J. T. Shotwell, *Journal of Philosophy, Psychology and Scientific Methods*, XII.

2 Egyptian papyrus of the beginning of the Christian era is still extant.

Naturally the revolution of the moon and the sun served for fixing the standard by which Time was to be measured. The ancient thinkers were struck with the daily appearance and disappearance of the moon and the sun. Consequently the movement of the moon or the sun was chosen to fix the measure of Time. The early religion of the ancient nations reveals an intimate knowledge of the times an seasons, and there was from the earliest times an attempt to prepare a calendar setting forth the order in which the rites and ceremonies of the nations should be observed. This calendar, in the earlier periods, was of an imperfect character, which led to methods afterwards adopted for its improvement, generally with a view to its adaptation to religious rather than to secular uses.

The ancient Hindus prepared their calendar mainly for sacrificial purposes, and the performance of various sacrifices facilitated the maintenance of the calendar. When the course of sacrifices was completed, it was found that the year had also run its course, and the sacrifice and the year, therefore, became synonymous terms. There are several sacrificial hymns in the Ṛgveda (3000 B.C.), which show that the sacrificial ceremonies must have been considerably developed; and as no sacrificial system could be developed without the knowledge of months, seasons and the year, it will not be too much to presume that in the Vedic times there must have existed a calendar to regulate the sacrifices. It is difficult to determine the exact nature of this calendar, but a study of the sacrificial literature would show that the phases of the moon, the changes in the seasons, and the southern and northern courses of the sun were the principal landmarks in the measurement of Time in those early days.[3] The difficulties experienced by the Hindus in adjusting their calendar occasioned repeated changes of their system. At one period the motion of the moon was taken as its foundation, and the lunar month was formed to agree with the phases of the moon. The ancient Hindus found that the moon totally disappeared one night and again became full

3 Orion by B. G. Tilak, page 11.

and round another night; they called these phases new and full moon and further observed that from one new moon to another or from one full moon to another the sun rises thirty times. Hence one lunar month became equivalent to thirty days. Then a change in the calendar took place, and a solar month was formed, constituted so as to be reckoned by the time the sun, in its progress, remained in each sign of the solar zodiac. Another change followed, efforts being made to reconcile the two previous systems, in which each kind of month preserved its original character, the solar month being reckoned in ordinary civil days, and the lunar months measured by lunar days, each being one-thirtieth part of a synodic period, the time elapsing between two conjunctions of the sun and the moon. The result of these efforts was the formation of the luni-solar year, either in civil days or in lunar days. The Hindus further observed that the star that rose or set at sunrise one day would not do so after the lapse of several days. They concluded that the sun like the moon moved among the stars in the heavens and that the sun took twelve months to complete this course. Thus according to this calculation a year contains twelve months. The Hindus made several changes regarding the beginning of the day. The Vedic and the Paurāṇic literature maintained that the day began with sunrise; but different theories on this question were advanced by the later Hindu writers. Āryabhaṭa maintained that the beginning of the day is to be reckoned from sunrise at Laṇkā. Varāhamihira held that the day begins from midnight. In fact there is mention of four kinds of day-beginnings, namely, from sunrise, from mid-night, from mid-day and from sunset.[4] The division of the calendar into years, months, weeks and days evolved gradually but the system was almost complete in the Vedic and the Paurāṇic ages. Slight modifications were introduced later on by the Hindu astronomers and this modified calendar has been since then in vogue in India. The Hindus at a very early date invented the sundial (gnomon measur-

4 Vide a paper on Hindu Calendar by Sukumar Ranjan Das, *Indian Historical Quarterly*, September, 1928.

ing twelve fingers) to measure the sun's shadow from which time was determined. The observation of the increase and decrease of the shadow of a tree must have struck them with the idea of a gnomon. But though the gnomon was sufficient to measure the time during the day, it was not possible to use it after dusk. The water-clock or clepsydra (a metal bowl floating in a vessel of water where the amount of water that mesures a nāḍika or 24 minutes is given) was, therefore, invented by the ancient Hindus. In fact, they became so skilful in the use of water-clock or clepsydra that they could find out the exact time at a mere look at the instrument. There was also another instrument called yaṣṭi or staff to measure the time from sunrise or the time after mid-day.[5]

The Chaldeans knew the length of the year as 365 days 6 hrs. 11 min., but used both the lunar month and the lunar year for civil purposes. They divided both the natural day and the natural night into twelve hours each. They invented the sun-dial and the water-clock to measure time, the former was used during the day and the latter during the night. For astronomical purposes they divided the day into twenty-four equal hours. They also used very early a fourth of a month as a convenient division of Time; this was probably half of the half month as was customary in ancient world.[6]

Earlier than 2000 B.C., the Chinese attempted to prepare a calendar. But the system at first changed with each emperor. Under the emperor Yan (c.2357 B.C.- c.2258 B.C.) an effort was made to establish a scientific calendar for the whole country, and possibly this was done even earlier, under the emperor Huang-ti (c.2700 B.C.).[7] There is evidence that according to a decree of Wn-wang (1122 B.C.) the day was arranged to have begun with mid-night, although before this under the Shang dynasty (1766-1122 B.C.) the day began at noon. In the Chinese calendar the civil

5 Siddhānta Śiromaṇi, Golādhyāya, Chapter XI, verses 28-30.

6 "Resume de Chronologie Astronomique", by J. B. Biot. *Memoirs de l'Academie des Sciences*, XXII, pp. 209-476.

7 History of Mathematics in China and Japan by Mikami, pp. 5-45.

day has twelve hours and the middle of the first hour is mid-night. These hours which were called shi in the Chinese language are each 120 European minutes in length. Each hour is again divided into eight parts called khe which is equal to $\frac{1}{4}$ of an European hour. Each of these parts is then divided into 15 fen, one fen being equal to one European minute. Each fen is again divided into 60 miao, one miao being equal to one European second. At present also the American clock is becoming common in China. The Chinese days were named in such a way as to give seven-day periods and the month began with new moon.

As early as the 14th century B.C. the Egyptians recognised the value of a fixed year, but the changing one was so strongly implanted in the religious canons of the people that it could not be possibly given up. The fixed year was used to the extent of a division into three seasons, regulated by the river,—the Water Season, the Garden Season, and the Fruit Season (namely, June 21 to October 20; October 21 to February 20; February 21 to June 20). These were easily determined by the temple observers. They were left with the determination of the seasons and were the principal calendar-makers. From the temple, too, came the announcements of the turn in the rise or fall of the river, the nilometer being under the observation of the temple-priests.[8] In the ancient Egyptian calendar, the business day included the night, the natural day and night being each divided into twelve hours, these hours varying in length with the season. The civil day seems to have commonly begun at sunset. But it is said by Pliny that the priests began their day at mid-night. In later times the civil day began at noon, and was divided into twenty-four equal hours. This was also the case with Ptolemy, the astronomer (c.150 B.C.). In the native Egyptian calendar each month except the last (Mesori) contained thirty days; five days used to be added to Mesori so as to make the year equal to 365 days. This gave error of $\frac{1}{4}$ day. The year was a changing one and came back to its original position

8 For the details vide The Evolution of Calendars by M. B. Cotsworth, Washington, 1922.

with respect to the heavenly bodies once in 4×365 common years or 1460 years (1461 Egyptian years). The year began with the first day of month Thoth, the God, who was supposed to introduce the calendar and numbers into Egypt.

After Egypt became a Roman province (c.30 B.C.) the Alexandrian calendar, including the fixed year, was introduced, although the varying year remained until the fourth century A.D. The Alexandrian system was used till the first half of the seventh century (till 638 A.D.) when Alexandria yielded to Mahammadan conquest. There was then a change in the calendar except in Upper Egypt. In later days when the French obtained brief control of Egypt in 1798 the European system was used in Egypt side by side with the Mahammadan system.

The Athenian calendar[9] followed the Egyptian in beginning the new day at sunset and in dividing both day and night into twelve hours. The seven-day week was not used. However, the lunar month was divided into three parts. The first part was equal to ten days numbered in order, the "fifth day of the beginning of the month" being the fifth. Then followed nine days, numbered as before, but with the designation "over ten," i.e., "one over ten" and so on to "twenty." Then to the end of the month the numbers were "one over twenty" and so on. These days were also used to be numbered backwards from the end of the month. In the popular calendar the month began with the new moon, and twelve of these months made 354 days, requiring the insertion of a new month every three years. This was called the second month of Poseideon, known as Poseideon II. In 432 B.C. Meton constructed a nineteen year cycle in which the third, fifth, eighth, eleventh, thirteenth, sixteenth and nineteenth years used to contain the extra months. Nineteen years contained two hnndred and thirty-five months and were equal to 6939 $\frac{3}{4}$ days. These months as arranged, however, contained 6940 $\frac{2}{3}$ days. In 325 B.C. Callippus modified it to include four nineteen year cycles. 4×19 years $= 76$ years $= 940$ months. The months were 29 or 30 days and therefore

9 History of Mathematics, vol. II by D. E. Smith, pp. 660-664.

940 months were equal to 27759 days. Still later in 150 B.C. Hipparchus suggested the use of four of the cycles of Callippus. But none of the last two calendars ever came into popular use.

The Romans considered the planets as ruling over one hour of each day, in the following order, beginning with the first hour of Saturday: Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon. At that time the sun and moon were placed among the wanderers (planets). Taking Saturn for the first hour of Saturday and counting the hours forward we find that the second hour is ruled by Jupiter and so on to the twenty-fourth, which is ruled by Mars. Then the next hour, the first of Sunday, is ruled by the Sun, the first of the next day by the Moon and so on. Thus the days of the week were named after the ruling planets of their first hours. Hence we have Saturn's day, Sun's day, Moon's day, Mar's day (French Mardi), Mercury's day (French Mercredi), Jupiter's day (in the northern lands, Thor's day), Venus's day (Frigg's day, Frigg was the goddess of marriage). The oldest of the Roman calendars is attributed to Romulus, the founder of Rome. The year then probably consisted of ten months of varying lengths, or of 304 days. The year began with March. Numa Pompilius (715-672 B.C.) added two other months, January and February, and his year was probably lunar. In the fifth century B.C. the Decemvirs decreed a solar year, the regulation of which was left in the hands of the priests. The calendar was so mismanaged that by the time of Julius Caesar each day was eighty days out of its astronomical place. Radical measures were, therefore, necessary for the reform of the calendar and Caesar decreed that the year 46 B.C. should have 445 days and that thereafter the year should consist of 365 days with a leap year every fourth year. The difficulty arose thus; the ordinary civil year contains an exact number of days, viz. 365, but the time taken by the sun to complete a revolution in the ecliptic is about 365¼ days and the exact interval between the successive vernal equinoxes is 365 days 5 h. 48 m. 45·5 sec., which is the tropical year. Therefore, by taking the civil year as 365 days, there is an error compared with the tropical year of 5 h. 48 m.

45·5 sec., which in four years amounts to 23 h. 15 m. 2 sec., or very nearly a day. If this error was not corrected, the result would be that the dates of the equinoxes and solstices would be later by one day every four years. The first exact attempt at approximating the length of the civil to that of the tropical year was made by Julius Caesar. It was then agreed that an additional day should be given to every fourth year, which was to contain 366 days. Caesar followed the following plan to determine the names of the months and the number of days to constitute each month :

Names of the months	Number of days
1. Martius	31
2. Aprilio	30
3. Maius	31
4. Junius	30
5. Quintilis	31
6. Sextilis	31
7. Septembris	30
8. Octobris	31
9. Novembris	30
10. Decembris	31
11. Januarius	31
12. Februarius	28

Here the year was made to begin in March. An account is also found for the origin of the nomenclature of September (seventh month), October, November, and December. In his original plan Caesar caused every alternate month, beginning with March, to have 31 days, the others having 30 days, except that February received its 30th day once in four years, otherwise it had 29 days. Later Julius Caesar decreed that the year should begin with January. Finally, during his life-time he changed the name of Quintilis, the month in which he was born, to that of Julius, after his own name. He also changed that number of days in certain months and the result was the present Julian calendar. After the death of Julius Caesar and in the second year of his calendar a further confusion arose, apparently through a misunderstanding

on the part of the priests as regards the proper date for leap year. This was corrected by Augustus, and in his honour the name of Sextilis was changed to bear his name. Since then the Julian calendar was in vogue till it was further reformed by Pope Gregory XIII in 1582. According to the Julian calendar a correction was made of one day in four years. But one day, or 24 hours, was in excess of 23 hrs. 15 min. 2 sec. by about 45 minutes. Thus the correction by means of leap year led to a new but very much smaller error of about 45 minutes in four years, or an average of rather more than eleven minutes each year. This error in 400 years would amount to nearly three days. Hence was the necessity of the Gregorian correction to the Julian calendar adopted by Pope Gregory, according to which each year which is a multiple of 100, such as 1700, 1800, 1900, which by the Julian calendar are leap years, should be ordinary years, with the exception of those years in which the number of the century is divisible by 4 without remainder, such as 2000, 2400, which should remain leap years. This arrangement evidently makes the required correction of three days in 400 years. Even with the Gregorian correction there is still a very small error, which, however, would amount to not more than a day in 20,000 years. The Gregorian correction was not adopted in England until the year 1752, when the accumulated error, as compared with the corrected calendar, amounted to eleven days. Eleven days of 1752 were, therefore, skipped, the 2nd of September being called the 13th. The Julian calendar was used by the Greek catholics, including the Russians until the World War of 1914-1918, the dates at that time differed by thirteen days from those of the calendar of Western Europe where the Gregorian correction was adopted.

It is interesting to note that in the early centuries the year in the Christian calendar usually began with April in the east of Europe[10] and with March in the west, although sometimes with the Feast of the Conception, Christmas day, Easter, or Ascension day, or at other times according to the fancy of the Popes. In Spain until the sixteenth century and in Germany from the 11th

10 The Byzantine Calendar began with September 1.

century, March 1 and March 25 were the favourite days to make the year-beginning, although Advent Sunday (the fourth Sunday before Christmas) has generally been recognised as the beginning of the ecclesiastical year. March 1 was generally used in mediaeval France for beginning the year. The same was the custom in oriental Christiandom, and in Venice until 1797. March 25 was used by the mediaeval Pisans and Florentines for the year-beginning. In Italy Pope Innocent XII decreed that the year should begin on January 1, beginning with 1691, as Philip II had done for the Netherlands in 1575, and as Julius Caesar had done before the Christian era. Most of the Italian states adopted January 1 in 1750. England adopted it in 1752.[11]

We may mention here that there is evidence of several changes of the year-beginning in the Hindu calendar. In the early Vedic times the year began when the sun was in the vernal equinox. Later on, the commencement of the year was changed from the vernal equinox to the winter solstice. It is difficult to ascertain definitely the time of the change. Now to understand this change in the beginning of the year, it is necessary to remember that the solar year was sidereal and not tropical in the case of the Hindu calendar, and that the great object of the calendar was to ascertain the proper time of the seasons. This necessitated a change in the beginning of the year, every two thousand years or so, to make it correspond with the cycle of natural seasons. The difference between the sidereal and the tropical year is 20·4 minutes, which causes the seasons to fall back nearly one lunar month in about two thousand years, if the sidereal solar year be taken as the standard of measurement. Therefore, the beginning of the year was twice altered owing to the precession of the equinoxes. The third change in the year-beginning was introduced at the time of the Vedāṅga Jyotiṣa (about 500 B.C.), when the seasons had further receded by a fortnight and the beginning of the month was altered from the full-moon to the new-moon during this period. The next

11 History of Mathematics, vol. II by D. E. Smith, page 651 and pages 661-670.

change was introduced and put into effect by the astronomer Varāhamihira in the beginning of the sixth century A.D., and this last system is even now being used in India.[12]

The Jews began their day at sunset, their week on Saturday night (i.e., when their holyday ends and Sunday begins) and their year with Fishi 1 (the first new-moon after the autumnal equinox).[13] Their calendar was lunar. In the ancient Maya civilization the year began with the winter solstice, it was divided into eighteen months and was entirely independent of astronomical considerations. Scholars assert that their calendar goes back to the thirty-fourth century B.C. The Mahammadans began their day with sunset, divided both day time and night time into twelve hours, the length of the hour varying with the season; their week began on Sunday, their month with the new-moon, and the year was purely lunar of 354 or 355 days.

When the year-beginning was fixed it was found necessary to determine the date from which the years were to be numbered. In India the Śaka era which is 78 years behind the Christian era is generally followed, i.e., the date of accession of a famous Śaka king is taken to number the years. In Europe, following the Roman custom, the years in the early centuries were dated from the accession of the emperor or consul until the abbot Dionysius Exignus (533 A.D.) arranged the Christian calendar in such a way as the supposed date of the birth of Christ was generally taken for the beginning of the era. This era was adopted in Rome in the sixth century. The Mahammadans begin their era from the date of birth of their Prophet, Mahammad. To get the Christian year from the hejira (Mahammadan year), we add 623 to 97 per cent of the number of the hejira year, e.g., 1300 A.H. $= \frac{97}{100} \times 1300 + 622 = 1883$ A.D.

In early days of the French revolution an attempt was made to impose a new calendar upon the country, partly as a protest

12 Seasons and Year-beginnings of the Hindus by Sukumar Ranjan Das.

13 Elements of the Jewish and Mahammadan Calendars by S. B. Bunday, London, 1901.

against the Christian Church. The calendar was to begin with the autumnal equinox on September 22, 1792. The months of this calendar were named according to natural conditions.

Of the chief divisions of time the most obvious one was the day. This was, therefore, the primitive unit in the measurement of time and the one which for many generations must have been looked upon as unvarying. As the human race developed, however, various kinds of day were distinguished. First, from the standpoint of invariability is the sidereal day, the interval of time taken by the fixed stars to complete a revolution round the pole, namely, 23 hrs. 56 m. 4·09 seconds of our common time. But from the standpoint of the casual observer, however, first is the true solar day, the length of time between one passage of the sun's centre across the meridian and its next passage. This latter day varies with the season, the difference between the longest and shortest day being 51 seconds; but for common purposes the solar day sufficed for thousands of years and the sundial was frequently used to measure the length of time. As clocks became perfected a third kind of day came into use, the artificial mean solar day which is the average of the variable solar days of the year and equal to 24 hrs. 3 m. 56·56 seconds of sidereal time. In addition to these general and obvious kinds of day there are others which have been mentioned by the writers on chronology. With the Babylonians the day began at sunrise; with the ancient Hindus it began at sunrise or mid-day or mid-night or sunset at various periods, but most generally form sunrise; with the Athenians, Jews and various other ancient peoples and with certain Christian sects at sunset; with the Umbrians at noon or mid-day; and with the Roman and Egyptian priests at mid-night.[14]

The next obvious division of time was the month; it was originally the length of time from one new-moon or one full-moon to the next. This was generally used by the ancient nations and served as the greater unit for many thousands of years. However, as science made considerable progress, it became apparent, as in

14 Ancient Calendars and Cycles by Plumett.

the case of the day, that there are several kinds of months. There is a sidereal month, the time required for a passage of the moon about the earth as observed with reference to the fixed stars, namely, 27 days 7 hours 43 minutes 11·5 seconds. There is also the synodic month, the interval of time from one conjunction of the sun and the moon to the next, the average length of which is 29 days 12 hours 44 min. 3 sec. or 2 days 5 hrs. 0 min. 51·5 sec. more than the sidereal month. This is the month used by those among whom a lunar calendar is in vogue. It is the basis of the artificial month, twelve of which make our common year.

Less obvious than the day or the month is the year, both sidereal and tropical. A sidereal year is the time taken by the sun to return to the same position relative to the fixed stars, and a tropical year is the exact interval between two successive vernal equinoxes. But the ordinary civil year which is in use contains an exact number of days, viz. 365 and the time taken by the sun to complete a revolution in the ecliptic is about 365¼ days. Probably at first the year recognised by the primitive nations was the lunar year consisting of twelve synodical months and is even now used in some parts of the world, specially by the Mahammadans.

The least obvious division of time was the week. It seems very likely that it arose from the need for a longer period than the day and a shorter than the month. The Chaldeans were the first who named the seven days of the week after the respective presiding planets and it is believed that the Hindus got this practice of naming the seven days from the Chaldeans.[15] The Romans also named the days of the week after the supposed presiding planets. This division of the week into seven days is in vogue throughout the world. But recently in Soviet Russia there has been an attempt to make the week contain five days, to be named after the five principal planets excluding the sun and the moon. Probably the week was conceived to be made up of seven days, as according to the ancient nations there were seven planets including the sun and the moon.

15 Indian Astronomy (in Mārāthi language) by S. B. Dikshit, p. 138 f.

In all the ancient calendars there were usually twelve hours in the day and twelve hours in the night. It is still a mystery why the number 'twelve' was chosen. Some suggest that the reason is found in the custom relating to the Babylonian knowledge of the inscribed hexagon. Some again say that this was selected because from twelve the fractions $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ could easily be obtained. The day hours are longer than the night hours in the summer, and shorter in the winter. This fact is referred to by several ancient writers.[16]

To find the hours of the day the shadow cast by some obstruction to the sun's rays was used. Then an artificial gnomon was erected and lines were drawn on the earth to mark off the shadows. Since the houry-shadow is longer when the sun is near the horizon, either concave surfaces or curved lines on a plane were placed at the foot of the gnomon. The sundial was first used in Babylonia, in India, and in Egypt. From Babylonia it came to Greece where it was introduced by Anaximander (c. 575 B.C.). In the sundial of that period the gnomon was placed at the centre of three concentric circles. But very often there were difficulties with the gnomon. At times when the sky was cloudy the gnomon did not cast a distinct shadow. Hence the need was early felt for some kind of device to tell the hours at night as well as during the day in cloudy weather and also when the sun's rays were direct. Various methods were employed by the early nations, such as burning of tapers, hour-glasses and water-clocks (or clepsydra). The hour-glass was known as early as 250 B.C. Plato gave much thought to the subject, and his conclusions might have suggested to Ctesibius (c.150 B.C.) the idea of a water-clock. The clepsydra was of earlier origin. There is mention of this instrument in the Vedāṅga Jyotiṣa (500 B.C.). The clepsydra was introduced into Rome in 159 B.C. In the early form water trickled from one receptacle into another in a given time, as the sand in an hour-glass. It was till recently in operation in one of the ancient towers of Canton in China. All these instruments led

16 History of Mathematics, vol. II by D. E. Smith, pages 668-670.

to the invention of the clock. In the middle ages Boethius (480 A.D. to 525 A.D.) invented a clock (c. 510 A.D.) and it was used in churches as early as 612 A.D. The invention of clocks driven by weights is ascribed to Pacificus, archdeacon of Verona, in the 9th century A.D. The pendulum clock was introduced about 1657 A.D. and was cheifly due to Huygens.

An attempt for the measurement of time and to fix the hour of the day as well as to prepare a calendar for practical purposes is as ancient as the human race. The evolution has, no doubt, been gradual, but the introduction of Time in chronology dates to a prehistoric period and it has passed through various stages from the ancient down to the modern age.

Insects and Disease

By Purnendu Sen (Calcutta).

That insects are remarkably instrumental in causing havoc and destruction is an experience of man not of recent years alone, but we find its mention even as far back as in the days of Pharaohs and the ten plagues of scriptures. Whatever little people knew of the nature of destruction through the depredation of these six-legged creatures in the sphere of agriculture and industry in the olden times, it was not until very recently that the importance of the insects in propagating disease was recognised.

This relationship of insects to disease comprises a special branch of biological science known as the Medical Entomology which has made an enormous pace since the last Great War. The war proved decisively and not without pains that the study of the insects, even during such calamities in the life of a nation, is an absolute necessity, and as a matter of fact an economic proposition, and not a luxury as some candid politician might say. The body louse alone was found to be responsible for the collapse and distress of the Serbian armies acting as a vector of trench fever and typhus, and was also responsible for the one-half of the inefficients on the Western front during 1917-18.

Trench fever took such an alarming nature during the war that the American Redcross Society thought it obligatory to appoint a commission to investigate into the matter and to devise means of relief. The disease was formerly taken for a modified form of typhoid or paratyphoid fever. It was only through the untiring researches of this commission that the real nature of the disease became evident and it transpired that the fever was due to a filterable virus present in the plasma of the blood of a patient being spread by the common body louse (*Pediculus humanus corporis*).

Medical entomology thus aims at investigating the role of insects in causing diseases and its objects are to assess the amount of illness or suffering dissipated by the insects, to find out the exact source of illness, and to devise means to control them. These necessitate the possession of not only a knowledge of the insect or a knowledge of the disease but also an intimate knowledge of the relationship of the insect to the disease. But to possess the knowledge of the insect alone is a task by no means easy. Once an insect has been suspected as a vector of a disease the task for the entomologist would be to get it correctly identified. This often is time-consuming as we may have to send it to foreign countries for confirmation of species. But the real difficulty arises when he gets to study the life history and biology of the insect so essential in all control work. Often this will take several years' persistent study before one can say anything definitely about even a part of the life processes of the insect in question.

In order to control the insects efficaciously, they should be attacked at stages, generally the early stages either as eggs or larvae, when they can be suitably tackled, and unless the bionomics of an insect is thoroughly worked out, these stages are apt to be missed. Here lies the real importance of the biological studies, time-consuming though they may seem at the beginning. The practical man, our financier, in the meantime will perhaps grow impatient and suggest why waste time and money on these elaborate studies but strike outright at the insects which appear to be the cause of the trouble or malady. This urge from the financier has well been taken advantage of by the commercial people and to-day the market is beseiged with various unintelligible brands of insecticides and sprays. There is a wrong conception cherished by average man that killing the insects indiscriminately by some poisonous sprays or gases would remedy the whole matter. While this may be a good proposition, it cannot, however, be achieved in practice.

In trying to control the insects at their young helpless and innocent stages recourse is no doubt taken to poisonous gases and sprays. But this is really a palliative method apart from the im-

pression, spectacular or otherwise, that it may have on our clients that vigorous efforts are being made to eradicate the pest. All that an entomologist attempts at and can reasonably attain is to keep the insects under human check, so that they may not be as appreciable a mischief-maker.

Much time and money may, however, be saved by adopting some more effective methods which often follow better sanitation and hygiene. It is a common experience of all public health workers that improvement in the nature of human habitation and observance of personal hygiene often will lead to miraculous results in reducing to a negligible number the disease-carrier insects from a locality. For the same reason an industrial entomologist directs his activities firstly in clearing the ware-houses and wharfs to oust the grain pests from the marketing countries, an agricultural entomologist falls back on improved agricultural methods and better tillage and drainage, and a forest entomologist depends chiefly on sound silvicultural practices and so on. Unfortunately this opportunity has not been properly seized by the common people as they would not believe in such comparatively simple solution.

The writer recalls an instance when in a small family party, the hostess asked whether I could do something for a friend of hers who is being greatly troubled with an influx of house flies. On visiting the house, I gathered that the young lady has tried all sorts of sprays procurable at the local chemist with very little improvement in the situation. I started examining the place and found that the flies were sheltering in the iron beams on the roof, on sooty strings, and on the ends of the electric wires for ceiling fans which were no longer in use, hanging from the beams. The situation was aggravated by the insanitary arrangement of the store-rooms where grains and vegetables were lying about uncovered and the 'what-nots' sticky with a combination of various food substances, liquid and solid. The beams were painted white and the groove of the T-shaped beams covered with fly-proof papers, all cobwebs and hangings from roof and walls removed, extra sanitary measures were adopted in the kitchens and store

rooms and in no time the flies in the place were appreciably reduced.

Apart from the annoyance the house flies cause by sitting on the face and body and buzzing around us, they are important carriers of disease germs. House flies have been long known to contaminate man's food with bacilli of cholera, summer diarrhoea, dysentry and typhoid. When a fly sits on the stools of such patients, the body of the fly becomes infected with the disease-producing organisms or bacilli; this fly may then transfer the foul organisms to our food by mere contact with it. Or the fly may ingest the faecal organisms which multiply in the intestine of the insect and such a fly may pass on the organisms to our food through its excreta. It is, therefore, a safe principle to avoid food which has been visited by house flies, wherever possible.

The extermination of house flies then is more a sanitary proposition than of any prime pathogenic importance since they are not associated with any single disease and their extermination would not wipe out altogether any germ pathogenic to man. The fly by virtue of its domestic habit and characteristic feeding acts as an involuntary or accidental carrier of the various germs mentioned above. But this is no speciality of the flies. Any insect visitor in the house may act similarly if it by chance or error happens to infest the body with some d'sease germs.

A closely allied form viz. the tse-tse fly (Glossina), the principal insect vector of sleeping sickness or trypanosomiasis presents a different aspect of vectorial predominance to that of the house flies. The Glossina are blood-sucking viviparous insects of great agility and are specially restricted to Africa. The tse-tse fly has been known to get the infection from the wild animals which are considered as the 'natural reservoirs' for the disease germs, but the insect may also acquire the germs from human beings suffering from sleeping sickness as has been observed in *Glossina palpalis*. The fly taking the infection develops the trypanosome parasites within its gut and after about three weeks or more, the parasites invade

the salivary glands of the insect where the pathogenic protozoan organisms remain infective as long as the fly lives.

The entomology of the Glossina, which although are known to be carriers specific in nature, thus affords a special difficulty because of the ever-present animal reservoirs of trypanosomes, and the problem of control is much more complicated than in any other vectorial forms dealt in this article. The wild animals will always remain the source of danger. Here we go a step further than mere sanitary precautions as the insect has to be controlled by reducing its chances of carrying the infection from the wild animals which supply the blood meals to the fly, in other words, the tse-tse fly requires controlling by disbalancing its natural food supply. But by what methods this food supply may be best controlled, the entomologists are still at variance.

While talking of the flies, I may mention the genus Stomoxys, another group of blood-sucking flies but of minor importance. These flies, though they are pests mainly of the domestic animals such as cattle and horses, will also attack men occasionally and are credited for carrying the anthrax and surra disease (a form of trypanosomiasis) amongst men merely by mechanical methods.

A typical example of the application of the knowledge of insects in preventive medicine is supplied by the anopheles mosquito, which, so far as our knowledge goes, is the sole carrier of the malaria germ Plasmodium. Here is an insect which is associated with one of the worst and easily contractable diseases that man may suffer. The malaria germ, a protozoon of the group sporozoa must pass a part of its life cycle within the anopheles mosquito if the disease has to be spread amongst men, thus unlike the non-blood-sucking house flies the successful elimination of the anopheline mosquitoes would undoubtedly control a specific disease, viz., the human malarial fever. A wonderful link is found to exist between the man, the protozoon parasite and the mosquito, and if the link can be effectively broken anywhere in the chain, the malaria would forthwith subside.

In a patient attacked with malaria fever the parasite undergoes development asexually within the blood and there the sexual forms

known as the gametes appear. The parasites after this stage, if sucked with the human blood by certain mosquitoes of the genus Anopheles, would pass into the sexual phases inside the gut of the insect and by the union of the male and female gametes the familiar zygotes of the malariologists result. The cytoplasmic contents of the zygotes or the mother cells at a later stage undergo several divisions and modifications till the minute thread-like bodies, the sporozoites, are found. These elongated vermiform bodies or the sporozoites as they are called technically, subsequently invade the salivary glands of the mosquito and once lodged in these glands, the parasites find an easy passage to the body of a healthy person when the infected mosquito bites such a person. Thus an apparently healthy person contracts malaria, often unaware, through the visitation of an infected mosquito into his abode or place of repose.

Since as I have said, if the link between the man, the mosquito and the parasites be broken, malaria would disappear substantially, the entomologists maintain that every practical malariologist should divert his whole-hearted action against the mosquitoes as the principal measure for controlling the malaria fevers. That is why we hear so much talks in recent years about the mosquito control schemes in all malarious countries.

Malaria is believed to have existed in India from very ancient times and the writers of Hindu medicines, in ages ago, recorded in their own way about the existence of the intermittent and remittent malarial fevers. In the Charaka-Sanhita, mention has also been made of the fevers being spread by mosquitoes. That mosquito is a menace to society has thus been long recognised, strange though it may seem that our city fathers have after all nodded their hoary heads from their exalted seats to launch a mosquito-control scheme for this metropolis only to-day.

Anopheles is not the only mosquito of medical importance; the mosquitoes of the genera Culex and Aedes (Stegomyia) are also implicated in the propagation of diseases. The Culex is responsible for transmitting Filaria worms which produce elephantiasis and other lymphoid varices amongst people. The stepping stone

of tropical medicine was laid by the discovery of this parasitic worm in the blood of man and here was the first parasite proved to be disseminated by a mosquito. The mosquito sucks up the larval worms of Filaria, which periodically appear in the peripheral circulation of an infected human host, while feeding on him. The parasitic worms attain their maximum size within the mosquito; these mature worms afterwards invade the proboscis of the insect. Here the worms wait for the mosquito to bite another person when they are injected into the abraded skin of the victim; the worms ultimately travel to the lymphatic tissues and in no time the elephantoid disease becomes obvious in the person attacked.

Aedes (Stegomyia) mosquitoes, in their turn, carry the germs of that dreadful disease called yellow fever amongst men. The disease is restricted to Africa and parts of South America, and fortunately for us, so far the disease could not establish itself in India, although the very species responsible for transmitting the disease is widely distributed in our country.

Yellow fever often assumes a blazing epidemic form in Africa. The disease is almost always fatal to the Europeans and other settlers, but the attack is milder in Africans. On serological tests it has been ascertained that the indigenous population of Africa carry the disease in a latent state and have attained a special merit of resisting the disease. The native of Africa through long sufferings has developed this partial immunity that he enjoys to-day, nevertheless he carries the germs of yellow fever and is a constant source of infection to the susceptible population. The premonition of the European in selecting his dwelling place away from the native population should not therefore be thought as an infallible indication of colour hatred. *Aedes (Stegomyia) fasciata* is also a carrier of *Filaria bancrofti* in the same way as Culex does, and carries the virus of dengue fever as well, so common in India.

Similarly, kala-azar, that scourge of eastern India and especially in Bengal and Assam, finds a suitable means of transport in the bodies of some moth-like midges of the genus Phlebotomus (Diptera). The kala-azar commission working in collaboration with the Calcutta School of Tropical Medicine and Hygiene have

shown in recent years the presence of the causative organisms for this disease, i.e. the Leishmania (Protozoa), in the midge *Phlebotomus argentipes*. This dipterous insect again acts as a carrier or porter of the germs of oriental sore, and in the Mediterranean region the papataci fever which usually remains for three days is carried by another species, *Phlebotomus papataci*.

One more group of blood-sucking dipterous insects, that is the genus Simulium deserves a reference here. Insects of this genus usually inflict fatal injuries to the domestic animals but one species from the Himalayas is said to be responsible for producing detrimental effect on human beings just as much as on the cattle.

So long we have been dealing with the two-winged dipterous insects. But then Diptera comprises only a fraction of the whole range of insects of medical or hygienic interest. At the present day we know about forty orders of insects, out of which seven find their place in books of Medical Entomology. Excepting Diptera then, there are six more orders containing forms of medical importance, and we presently pass on to some of them. Insects like the fleas (Aphaniptera), bugs (Rhynchota) and lice (Anopleura) representing three such orders are also associated each with at least one important human disease, although none of the three is considered to be exclusively responsible for the disease assigned to it. Hence their extinction at times of epidemics would certainly control the disease for the time being but cannot leave any permanent effect as was conceivable in the case of malaria by the extinction of Anopheles.

Now let us consider them separately, to begin with, the fleas, which are principally the carriers of plague bacilli amongst rodents especially rats, and from these to man, may be at once recognised by their wingless laterally compressed bodies with proboscis adapted for piercing and sucking.

The Indian Plague Committee have shown that in the common rat-flea (*Xenopsylla cheopis*) the infection is obtained from rats, the plague bacilli thereafter multiply within the stomach of the flea. A man gets the infection from faeces of such a flea, if the faeces are somehow rubbed against the abrasions caused by the

biting of the insect or by scratching the parts bitten. Recent observers, however, do not support this view, who hold that the bacilli, after the flea had a heavy blood meal from an infected rat, multiply within the stomach of the insect to such an extent that its proventriculus or the anterior part of the stomach becomes blocked. When the flea in this condition again attempts to feed, the sucked in blood being unable to penetrate the almost solid mass of the bacilli in the stomach of the insect, necessarily gets regurgitated which carries the infection to a fresh person.

Another flea, i.e. *Tunga penetrans,* causes the 'Chigoe' or 'Jigger' disease in man. This is produced by the female flea burrowing into the flesh where she afterwards transforms into the shape of a small globule, and to an uninitiated eye no trace of the flea would be visible. The part attacked becomes sore and gives intense irritation. Originally a native of South America, the insect has been carried to Africa through shipping and also introduced to ports of India only recently.

Turning to bugs, one naturally thinks of the bed bugs (Cimex) first. They are highly noxious insects and are despised by all civilised societies, not only for their irritating bites, but also for the idea that these creatures are associated with filthy and dirty surroundings. Bed-bugs in the mediterranean districts possibly carry the germs (spirochaetes) of relapsing fever, although lice would appear to be the proper vector for the disease. The bugs can be experimentally infected with the plague bacillus, Trypanosoma of sleeping sickness, and Leishmania of kala-azar, and an eye of suspicion may as well rest with them while dealing with the diseases mentioned. In nature, however, they have never been found to carry the germs of these diseases.

Besides, there are certain larger bugs belonging to the genera Triatoma and Rhodnius (Reduviidae). Insects of both these genera suck human blood at night, and certain Triatoma bugs have been found to be carriers of Trypanosoma in South America. The problem of bug-control then is a world concern, and amelioration of the slum position is a necessary corollary to any sound bug control scheme.

I have already spoken of the lice transmitting the trench fever among soldiers during the last War. They are highly active in crowded barracks and military encampments where the inmates do not get proper washes or laundering for days together. Here again the question of lice control is purely a hygienic proposition, they are seldom found on the body of a clean person. The lice, when present on the body of a person, may infest any conceivable part and at least three forms of them are distinguishable from the human body, viz. the head louse (*Pediculus humanus capitis*), body louse (*Pediculus humanus corporis*), and the louse from the public and perineal hairs (*Phthirus pubis*). Dispersal of these insects amongst folks usually is accomplished through direct contacts or they may be contracted by using the infested clothings or beddings of lousy persons.

The lice may as well act as carriers of relapsing fever as mentioned before, and so of typhus. The pathogenic organisms carried by lice may be transmitted to a healthy person by the insects voiding excreta containing these organisms into the abraded skin of the victim as had been noted for the trench fever, or the organisms may be passed on to the fresh host while the insects bite a person as is true for typhus, or the transmisssion may be effected by the lice being simply crushed and rubbed into the abraded skin as in the case of the relapsing fever.

So far I have discussed the important carrier species only, that is to say, the insects which are considered as dangerous for their capacity to transmit the various disease germs amongst people, although the species implicated in these diseases are mostly harmless in themselves. But that is not all; certain diseased condition of our body may directly be attributable to the dipterous insects, referred to as the myasis-producing Diptera in the medical professsion. Myasis is a term applied to all afflictions developed from the invasion of the fly larvae or maggots into the human or animal body. The maggots will often grow in neglected wounds and especially when a microbic infection of the skin has taken place; the larvae of blow flies or blue bottles (Calliphora), green bottles (Lucilia) and screw worm flies (Chrysomyia) have been obtained

from such places and the maggots of the last mentioned fly may also produce myasis in the passages of the body like urethra.

Larvae of Cordylobia (Diptera) are the main causative source for a type of boil in parts of Africa, the boil having a perforation in the centre through which the larvae breathe. And then there may be the myasis of the digestive canal, and the nasal, auditory and orbital cavities of human beings through the invasion of the dipterous larvae into such cavities. It is surprising how insects can lodge inside the human gut, larvae of about eighteen genera, some of which belonging to the order Coleoptera, have been recorded from this region.

There are yet to be mentioned a few more insects which are of minor medical and hygienic importance, for instance, the cockroaches (order Orthoptera), bees, wasps and ants (order Hymenoptera). Of these the cockroaches, as we all know, are the habitual guests of our stores and co-sharer of our food and in fact may infest any dark warm corners in our houses and godowns. They have been known to contaminate unsuspectedly our food and utensils with pathogenic organisms which, if consumed through our meals, may produce violent concussion in the human system. The bees, wasps and ants may inflict poisonous wounds which may need medical attendance, and therefore, these insects are included in the domain of medical entomology. It must not be contended that the list of noxious insects is exhausted here. There are still left some less important insects, since in an article like this it is not possible to describe them all, but then I hope I have been able to bring home the importance of the subject to my listeners from the descriptions of the insects I could give here. I have also purposely avoided the insects which spread diseases amongst cattle and other domestic animals.

Even if we take into account this comparatively small list of disease-carrying insects, it will appear that they can be ranked with the worst foes of man. The picture would no doubt appear much more amplified if we were to include the numerous insect pests of our principal industries. No wonder then that much of entomologist's time is spent on devising means of keeping down

any increase in the number of these insects, and I have mentioned in the beginning that better sanitation would bring about the desired result in most cases. If, however, better sanitation fails to check the influx of insects, very careful investigation has to be launched to find out the real source of this increase in insect population.

Insect outbreaks should no longer be regarded as indication of the wrath of gods; the public mind has been much more educated in recent years. Should they not take advantage of the offerings of science? Thirst for knowledge and pursuit after truth have taught the modern biologists that these outbreaks are determined by several environmental conditions, such as the climatic, food supply, edaphic and biotic factors, affecting the life of an insect. The interdependencies of these factors and the various implications involved in an insect outbreak are too numerous to mention here.

Because of these intricacies in the insect problems, the subject has gradually been slipping off the hands of the already over-burdened service amongst whom rank all the great pioneers in the field of tropical diseases, I mean the people whose main interests would naturally hover around medicine being members of that onerous profession, and more and more academic men and trained entomologists have stepped in as they are the best suited for the purpose. Entomologists to-day are not content with the mere study of insects from the zoologist's point of view although "the study of an insect as an insect must always be the basis of the entomologists' training and knowledge, narrow specialisation, formerly the chief barrier to the progress of economic entomology is gradually giving way before the advance of a wider and more catholic study of insect biology and of the relationship of the insect to its environment." The entomology as it is taught in modern institutions is closely linked with bacteriology, mycology, protozoology, chemistry and physics.

Throughout the centuries, the insect-borne diseases have fallen on the lot of mankind and swept away those unable to resist. It is well recognised that the power of resistance to the various forms of diseases differs greatly and while this depends partially on the physical condition arising out of the environmental tug-of-

war, inheritance also plays a great part. If these selective processes were not there to determine the resistant individuals, many species would undoubtedly become extinct. In Tropical Africa, it has been found that the Negroes are much more tolerant to malaria fevers than the Europeans, and in the United Kingdom, the British can resist consumption far greater than any Indian or other dark-skinned people. The tremendous significance of the endemic disease like the malaria in human society is hard to understand since the processes involved therein are so slow to act that they remain often unnoticed even by those actually suffering. Thus in some well-known quarters the opinion runs that the golden age of Greece passed away, never to return, not so much on account of wars and invasions as because of the selective action of malaria. There is also ample reason to believe that civilised man has practically destroyed the native tribes of West Indies, Tasmania and Polynesia mainly by introducing his diseases to these people and verily has it been said that his measles may be more dangerous than his fire arms. I fear I have now trodden on a highly controversial topic and the matters undoubtedly are somewhat speculative.

From all that I have said the insect affairs, as they affect the medical science, may appear to be hopelessly disappointing at first. A question may naturally arise 'can we profitably tackle the host of insects known to take a heavy toll on man's life and conservancy or at best telling adversely on the vitality of a nation? Panama Canal, an endemic malarious area, has been made healthy by controlling the anopheline fauna. Uninhabitable parts of Africa infested with tse-tse flies have been converted into prosperous colonies by the activity of the white settlers. The terai lands and the foot hills of our own country, once found to be unfit for spending a single night even because of malaria, kala-azar and like diseases, are being more and more reclaimed by civilised people. These are all glowing instances of the victory of man in the fight between man and insects and this has opened up many new avenues of robbing the soil out of its wealth. No wonder then that people think themselves as the 'Lords of Creation.'

On Ancient Indian Dream-Lore

By Sarat Chandra Mitra (Calcutta).

Men, in a low plane of culture, are unable to distinguish between dream-life and real life. The only explanation of the origin of this phase of their mentality is the belief of the savage man that he has a second self which has been away and has returned while weariness was snoring upon the flint, the second self—the soul, the ghost (armed with the ghost of the flint) was abroad. A similar event would take place at every place and with the same impression resulting therefrom whenever a savage man has watched his comrade sleeping, and subsequently listened to his account of what he supposes he did, while in reality his body never left the spot, there has arisen this one explanation possible, namely, that the sleeper's spirit quitted the body and went forth on its adventures.

A dream may be either the experience of the soul when absent from the body of the sleeper, or it may be a visit from the soul of the person or object dreamed of, as phantoms visit and converse with the professional spiritualist. The modern spiritualist believes that, while a person is in an unconscious state, his phantasm visits distant parts, and communicates with the living and the medium has the power of summoning also the spirits of the dead.

Even if the savage suspects some difference existing between dream-experience and real experience, his language does not enable him to express it. He cannot say: "I dreamt that I saw" instead of "I saw" therefore dreams must needs be narrated as realities, and this strengthens belief in them as such.

The belief in the existence of a other self having been thus established, the savage very readily account for the presence in

his dreams of parents, comrades or enemies known to be dead or at a distance; it is a proof that their soul still exists. For he naturally thinks that the persons, whom his spirit meets in dreams, the horse, the dog, the waving trees, are sprits also, and all inani-inanimate things seen in dreams are ghosts of the material things.

Many persons have a superstitious objection to waking a sleeper suddenly; savages are forbidden to do so, because the soul just then might be wandering, and not have time to return to the body, and then the sleeper would be a dead man. This savage belief has a striking parallel in the folk-lore of the modern Hindu of Bengal. The Bengalis also believe that during sleep the man's soul or other self leaves the sleeper's body and goes about wandering and encounters many adventures. An amusing story is told in illustration of this belief. It is as follows: Once upon a time a sleeper's other self left his body and being desirous of partaking of good food stored in an earthen vessel in a particular individual's kitchen entered the latter's cooking-room and went inside the pot to partake of that viand. The earthen pot was probably uncovered at that time. But after the sleeper's soul had entered it, the earthen platter which covered the pot somehow or other got into its proper position and completely covered up the pot containing the food. In consequence of this, the sleeper's soul could not emerge therefrom. When the day dawned the sleeper did not wake up as his soul was imprisoned in the vessel. He was taken for dead and preparation was then made for taking him out for cremation. But lo and behold, he suddenly waked up and sat up bolt upright just as a living man does. This was due to the fact that the cook by accident lifted up the earthen cover from the vessel inside which the sleeper's soul was imprisoned. As soon as this was done, the sleeper's other self emerged from the vessel, and returning to the body of the sleeper, who was supposed to be dead, re-animated it. Thus the sleeper supposed to be lifeless came to life again.

The foregoing incident is paralleled by one which happened in Central Europe and in which the sleeper died owing to her wandering soul not being able to find out its tenement of clay.

It is reported that in Thuringia at Saalfeld a servant-girl fell asleep whilst her comrades were shelling nuts. They observed a little red mouse creep out of her mouth and run out of the window. One of the fellows present shook the sleeper, but could not wake her up; so he moved her to another place. Presently, the mouse ran back to the former place, and dashed about, searching for the girl's body, and not finding it it disappeared; at the same moment the girl died.[1]

The savage belief that in dreams a man's soul or spirit goes through various sorts of activities and performs various kinds of adventures, and that the dreaming person believes his deam-actions to be real and vivid, is strikingly illustrated by the following incidents which Sir Everard im Thurn came across among the Indians of Guiana. He says: "One morning when it was important for me to get away from a camp on the Essequibo River, at which I had been detained for some days by the illness of some of my Indian companions, I found that one of the invalids, a young Macusi, though better in health, was so enraged against me that he refused to stir, for he declared that, with great want of consideration for his weak health, I had taken him out during the night and had made him haul the canoe up a series of difficult cataracts. Nothing could persuade him that this was but a dream, and it was sometimes before he was so far pacified as to throw himself sulkily into the bottom of the canoe. At that time, we were all suffering from a great scarcity of food, and, hunger having its usual effect in producing vivid dreams, similar events frequently occurred. More than once, the men declared in the morning that some absent man, whom they named, had come during the night, and had beaten or otherwise maltreated them; and they insisted on much rubbing of the bruised parts of their bodies."[2]

1 M. R. Cox, *An Introduction to Folk-Lore*. New and enlarged edition. London; David Nutt. 1897. p. 43.

2 Edward Clodd, *Animism*, London: Archibald Constable & Co., Ltd. 1905. pp. 31-32.

The interpretation of omens and dreams occupied a good deal of the attention of ancient soothsayers and augurs. "The flight of birds is another means of augury, a word which is, in part, derived from Latin *avis*, a bird. The Romans called the bird-seer *auspex*. We still talk of favourable auspices. The art of taking omens from birds and animals is familiar to savages and extends upwards to the civilised. In classic writings, there are many allusions to the divining powers of the seer, the feeder of the oracular birds. English people have their curious superstitions about birds, quite on a part with those of the Moari, the Tatar, the Dayak and the Kalmuc."

Then again: "*Animals and birds in dreams were interpreted as persons then as now; and the symbolical interpretation of dreams is not unknown either to the lower races.*"

The fact that dreaming of animals and birds prognosticates persons, or more psecisely speaking, the birth of persons is strikingly illustrated by two famous dreams which are recorded in the religious history of Northern India. When Māyādevī conceived the birth of Buddhadeva, the great founder of Buddhism, in her womb she saw, in a dream, that a white elephant was entering that part of her body.

Then again there is current in the district of Rangpur in Northern Bengal a folk-ballad connected with the cult of the godling Scnārāya. In line 42 of the first folk-ballad the following curious fact is stated, namely, that Krishṇa, assuming the form of a white fly, entered Yaśodā's womb. (Most likely Yaśodā saw this in a vision or dream, though it is not definitely stated in the ballad itself).[3] Subsequently Krishṇa was born as the godling Sonārāya.

Then again, coming to quite modern times, we find that among the people of the Bombay Presidency the dreaming of a pigeon held in the hands prognosticates the birth of a daughter

3 Vide my article entitled: "*On the Cult of Sonārāya in Northern Bengal*" published in the *Journal of the Department of Letters of the Calcutta University*. Vol. VIII.

to the dreamer. While if he dreams of the young ones of a pigeon, it betokens that many children will be born to him. If he dreams of a sparrow's nest it indicates that he will have many children. If a pregnant woman sees a kite in a dream it betokens that a handsome son will be born to her.[4]

The ancient Indians also had their dream-lore and drew omens and prognostics from the interpretation of dreams. We arrive at this conclusion from the study of Kādamvari (कादम्वरी) which is a famous prose romance composed by that eminent ancient Indian author Bāṇa, who flourished in the first part of the 7th century A.D. during the reign of King Srī Harsha at Kanouj.

In the aforementioned Sanskrit romance, there is an episode which runs to the following effect:—

In ancient times there lived in Ujjainī a mighty king named Tārāpīḍa and his queen whose name was Vilāsavatī. His minister was a Brahmana named Śukanāsa. Both the king and his minister were childless. Both the king and his minister passed some time in this way, both of them saw dreams which are described as follows in the undermentioned Sanskrit text:—

एवञ्च गच्छति काले कदाचिद्राजा क्षीणभूयिष्ठायां रजन्यामल्पशेषपाण्डुतारके जरत्पारावतपक्षधूम्रे नभसि स्वप्ने सितप्रासादशिखरस्थिताया विलासवत्याः करिण्या इव बिसवलयमानने सकलकलापरिपूर्णमण्डलं शशिनं प्रविशन्तमद्राक्षीत्।

English Translation

Thus as time rolled on once in the fading hours of the night and while the sky looked grey like the wings of an old pigeon, owing to a few lingering stars dimly shining, the king (Tārāpīḍa) saw in a dream the moon complete in all her digits entering the mouth of (Queen) Vilāsavatī sleeping in the topmost apartment of a white palace just like a bracelet of a lotus-stalk entering into the mouth of a she-elephant.

4 Vide Khan Bahadur Bomanjee Byramjee Patell's paper *"On a Few Dreams and Their Interpretation among the Natives of Bombay"* in *The Journal of the Anthropological Society of Bombay*, Vol. VII, pp. 136-147.

अद्य खलु मयापि निशिस्वप्ने धौतसकलवाससा शान्तमूर्त्तिना दिव्याकृतिना द्विजेन विकचं चन्द्रकलावदातदलशतमालोलकेसरसहस्रजटालं मकरन्दविन्दुसीकरवर्षि पुण्डरीकं उत्सङ्गे देव्या मनोरमाया निहितं दृष्टम्।

English Translation

I (Minister Śukanāsa) too have seen tonight in a dream a lotus placed on the lap of my wife Lady Manoramā by a twiceborn of heavenly appearance, of serene attitude and clad in garments all white—that full-blown lotus shedding minutely small drops of honey, fibrous on account of thousands of filaments gently moving and the hundred petals of which were as white as the digits of the moon.

Shortly after both the King and his Minister had dreamt the aforementioned dreams a son, who was named Chandrapīḍa, was born to the King. While a son, who was named Vaisampāyana, was born to the Minister. Both the prince and the Minister's son were equally handsome and possessed brilliant mental accomplishments.

We have already stated above that Māyādevī, when she conceived Buddhadeva in her womb, dreamed that she had swallowed a *white elephant*. While Yaśodā perceived in a vision that a white fly had entered her womb when she conceived Sonārāya. The colour white, therefore, betokened that the sons which would be born to them would possess divine attributes. Then again the bright effulgence of the moon which Queen Vilāsavatī swallowed in her dream and the full-blown lotus of which the petals were as white as the digits of the moon was placed on Lady Manoramā's lap by a Brahmana wholly clad in white garments betokened that the sons who were to be born to them would be extremely handsome in appearance and would possess super-excellent mental accomplishments.

But strangely enough, in modern Indian dream-lore of the Bombay Presidency the dreaming of such bright luminaries as the sun and the moon prognosticates quite different things. If one sees the sun he gets children, land and properties. If he dreams of

the moon he will have wealth and wisdom. If he sees himself in moonshine it is a sign of coming prosperity. But if he dreams of an eclipse of the moon the result will be disastrous to him.

Then again if one dreams of flowers he will have pretty children. If full-blown flowers are seen in the dream, the dreamer will have peace at home. If one sees in his dreams a garden of flowers, the subjects of a king will have peace and plenty.[5]

It will not, I hope, be out of place to mention here that even at the present day Bengali ladies, when *enceinte*, drink water or the milk of green cocoanuts by looking at the full moon so that the children in their wombs may be endowed with great beauty of appearance.

Analogous to the aforedescribed Bengali custom is that, prevalent among the ancient Greeks, of placing beautiful statues and pictures before pregnant women, so that by looking at them the children in their wombs may be endowed with great beauty. This is evident from the testimony of the following passage in Prof. Becker's *Charicles* which gives us a vivid picture of ancient Greek life, manners and customs:

"The fair enchantress (Cleobule) was this person's (Poleycles's) wife but Manes was unable to tell his name. 'What, married?' cried Charicles in agitation 'And to a sick old fellow?' continued Nausicrates. "By Hera, though, she was beautiful; tender and lovely as Aphrodite, with the life and bloom of an Artemis. Ay! ay! *the statues of both goddesses must have stood in her mother's thalamos (bridal chamber)*."[6]

In a note to the foregoing passage the learned Prof. Becker further says: "Such effects are commonly attributed to the frequent survey of beautiful statues, and even Empeodcles noticed the supposed fact. Plutarch, in his *de Plac. Philos.*, V. 12, refers to it. On this hinges the whole plot in *Heliodor. Aethiop*. IV. 8,

5 *Op. cit.*, pp. 137-147.

6 Vide *Charicles or Illustrations of the Private Life of the Ancient Greeks*. From the German of Prof. Becker. Translated by the Rev. Frederick Metcalfe M.A., New Edition, London: *Longman & Green & Co.* 1895. p. 128.

where the queen of the Aethiopians declares that she has brought forth a white child, because she had the image of Hesione before her," (see Galen, *Hist. Phil.* XIX, page 329). The same author also refers to it in *de Therica,* XIV, page 254. The reader may attach what credit he chooses to Oppian, *Cyneg.* I. 361, where it is stated that the Lacedaemonians placed before their pergnant ladies pictures representing "NIREA KAI NARKISSON, EUMMELIEN D' 'ANAKLUTHON."

In ancient India there lived a class of persons who used to earn their livelihood by interpreting the singnificance of dreams to those person who dreamt wonderful dreams and, being bewildered by the strange happenings in those dreams, wanted to know the meaning thereof. From a study of the Sanskrit prose-romance Kādamvarī which was composed by Bāṇa in the first part of the 7th century A.D. we learn that Queen Bilāsvatī, wife of King Tārāpīḍa, while very anxious to become the mother of a son used to dream strange dreams, and being keenly desirous of knowing the singinficance of the wonderful events she saw therein, consulted these dream-interpreters.

(स्वप्नदर्शनाश्चर्य्यान्याचार्य्याणामाचचक्षे ।)

Man and his Vegetable Kindreds

By Girija Prasanna Majumdar (Calcutta).

The relation between man and his kindreds of the vegetable world has been, is and will, in all human probability continue to be, a close, vital and an intimate one. This relation is being more and more increasingly recognised as time advances and as science unfolds the unknown and makes it thoroughly known to man in a variety of ways. Our vegetable kindreds, or to use a more prosaic term, "plants", occupy a prominent place in our material life supplying us with materials for commerce, giving us raw materials out of which domestic utensils, vocational instruments, etc., are to be made. We might go on adding items after items of service rendered to us by our goodly neighbours, plants. This will have the air of a commonplace, but a commonplace which will also have an element of romance.

Passing from the material sphere of our life to the intellectual and moral we find to our great astonishment and surprise that in these spheres too plants are moreways connected with us than we commonly think. In erotics, proverbs and popular sayings, social customs, literature, architecture, sculpture and painting, iconography and numismatics plants are found to play conspicuously important parts moulding our thoughts in a variety of ways. Men think, but they think on something; and our vegetable kindred constitutes a part of the sum total of things. In architecture they give us models, in our paintings they do exactly the same thing; in popular sayings, in metaphors and similies they supply us with means and materials for comparison and very naturally they help us in giving artistic expressions to our literary thoughts. Some of the roots of our words are supplied by plants. Literature would have been a poorer thing but for its association with our

vegetable kindred. In order to make distant near, near distant, abstract concrete and concrete abstract we must have recourse to a variety of literary devices and herein our vegetable neighbours lend us a helping hand. A mere weak being—a frail thing would have been prosaically described as a woman, but we add to the beauty, splendour and poetry of the thing by describing her as a creeper dependent on a harder creature, the tree. The beautiful face of a woman would have sounded a prosaic thing if we had simply called a spade a spade, but when one reads, or thinks, or imagines the lotus face of a comely lady the impression that is produced in one's mind is artistically a different one. Even the forbidden region of metaphysical speculations has been entered by plants and we find philosophers expressing themselves with the help of botanical similies in the Vedic, Upanishadic, Buddhistic and Pauranic literature.

The above is merely an indication of the parts played by plants in human civilization, especially the civilization of India—a topic with which I have exhaustively dealt in a thesis on *Plants in Ancient Indian Civilization and Culture,* a venture which I have been inspired to undertake mainly as the result of studying the monumental work, *History of Hindu Chemistry,* from the pen of the great sage, scientist and patriot in honour of whose 70th birthday this humble paper is being contributed.

Our ancient ancestors were not only related to plants, but studied them sincerely, thoroughly and scientifically, and built, we are sure, a number of sciences as a result of their speculations and study, some of which are lost, but some still live in fragmentary condition. Of these sciences, the sciences in which plants had their parts to play, are to be noted Medicine, Agriculture and Botany.

The perfection reached by the ancients in the science of Medicine, with which plants are intimately associated, is well-known to the world. The infant beginning in the Rik and Atharvanic texts, gradual progress, marvellous perfections reached in Charaka and Susruta, and the decline of the scientific spirit, which was superseded by the mythological one, constitute a story which I

have told in my own way in the second book of a treatise called *Vanaspati*, from which the following lines are quoted here: "The further story of the science of Medicine in India can be very briefly told. It is the story of monotony and stagnation—no development, no progress, no practical addition; rather, the spirit of enquiry, the desire of explanation, a hankering after the solution of each problem, the motive of searching analysis and scrutiny are all gone. In the Hindu science of Medicine, mythology with its vast array of gods and goddesses intrudes; and although the science has been practised, and it is being practised still with wonderful efficacy, the progress has been arrested for good and all. The wonder of wonders is that the Indian science of Medicine, which was developed centuries before the modern science of Medicine came into being, has stood so long the wear and tear of time, of revolutions and conquests, and in all essentials is still as perfect as 'the most developed European system' of to-day; and considered from the point of utility it is peculiarly useful and efficacious to the people of the land of its origin. The glory of it is that it can still cope with any other system of Medicine, and the misfortune and shame of it is that it has not received adequate attention and has not consequently undergone any improvement."

The allied science of Agriculture, as its name indicates, is also intimately associated with plants. Agriculture was not looked down on as an occupation for the low class of our society, but was practised with their own hands by our old ancestors, the Rishis. We have abundant materials in the Vedic texts showing the infant beginning of the science; we have the development of it indicated in the Arthasastra, Sukraniti and Krishi Parāśara. It is a pity that the science did not undergo further development, and I may in this connection as well reproduce my remark on the subject from the treatise mentioned above: "Our survey of the genesis and development of ancient science of Agriculture shows that after it has reached a certain state of perfection there has been no further improvement in the mode of cultivation, no accurate observation and no useful experiment. The scientific principles underlying

the art under unfavourable political circumstances came to be forgotten, and agriculture instead of being a concern of the state, a matter of expert knowledge, came to be the occupation of the lowest strata of the population with the result that the fertile India noted by Megasthenes and others for its absolute absence of famine became scenes of dearth and famine during the Mohammadan rules again and again, and many times during the British rule too."

Both the sciences of Medicine and Agriculture pre-suppose a knowledge of the science of Botany of which I am an humble student. It is clear that without a thorough knowledge of the science of Botany the sciences of Medicine and Agriculture could not have undergone the perfection they did. There was indeed a science of Botany in ancient India dealing with plants in a scientific way. Unfortunately with the decline and arrest of the scientific spirit at an early period of Indian history, it could not undergo any further deveoplment. It is difficult, but not impossible, to reconstruct a history of the science of Botany in ancient Inda, and I have attempted the task in my humble way in the first book of my *Vanaspati*, where I have tried to reconstruct the history of the genesis, development and decline of the science of Botany in ancient India with the help of Vedic, Upanishadic, Buddhist and Pauranic literature. It is clear from the evidences supplied by the Rig-Veda, Brihadaranyaka Upanishad, Agnipuranam, Vrihatsamhita, Sarngadhara Samhita, Vinaya texts and others that our ancient ancestors had a fair knowledge of what botanists call germination of seeds, descriptive morphology, physiology of nutrition including absorption, transport and manufacture of food. The phenomenon of the ascent of sap in plants, a baffling problem to plant physiologist, has been very briefly but ingeniously explained thus:

"Just as water may be drawn in through the lotus petiole applied to the month, so also plants (with roots) drink (absorb) water (watery solution) with the help of air." Thus the existence of a suction force in the leaves which is greatly accelerated by air and the uninterrupted passages for the water to go up the stem—

the two most important factors in the ascent of sap in plants—were known to our ancestors.

After the food materials are brought into the leaves the process of assimilation commences, which is also very naively described in the same treatise thus: "Agni (solar energy) and air (CO_2) help in the assimilation of the water (watery food materials) which is absorbed through the roots of the trees (and conveyed to the leaves). And it is on account of the assimilation of this watery solution that the vegetable kingdom undergoes development and becomes graceful." Here also we find that the knowledge of the two essential factors in the manufacture of food, namely, solar energy and CO_2, was already anticipated by them.

Our ancestors recognised plants as conscious beings capable of pleasure and pain, and in the organic evolution the plants were regarded by them as of lower grade than the animals. Their knowledge of the various methods of propagation, both natural and artificial, was astonishingly modern. In Taxonomy and nomenclature the ancient Hindus perhaps excelled their contemporaries. Sir William Jones was so much impressed with their method of naming plants that he wrote, "I am very solicitous to give Indian plants their true Indian appellations because I am fully persuaded to believe that Linnaeus himself would have adopted them had he known the learned and ancient language of the country." Each plant was given double names—one based on a salient morphological feature (Parichayajnāpikā Saṃgā), and the other on some prominent medicinal or other properties (Guṇaprakaśikā Saṃgā). Classification of plants was based on three principles, namely, botanical, medicinal and dietic; and with the exception of the botanical the other two classifications were at once scientific, thorough and exhaustive. The principles of heredity were discussed and understood, and in a way Atreya's "germplasm theory" was an advance on the conception of "gemmules" and "ids" of modern biologists.

It is a matter of pride for us that our ancestors anticipated the moderns in some of the fundamental discoveries of botanical science; it is a pity that the spirit which was at the root of it died

down. But it may be hoped that the scientific spirit which inspired our ancient ancestors will be revived, nay, it is being revived, under the influence of great pioneers who have combined the scientific method of the West with the illuminative intuition of the East.

The Preparation of Manganese Dioxide Sol

By M. K. Shrinivasan (Benares).

(Communicated by Dr. S. S. Joshi)

In view of its well-known and characteristic instability several methods have been elaborated by various workers from time to time to prepare colloidal manganese dioxide. Gorgeu,[1] and Spring and de Boeck[2] prepared this sol in electrolyte-free condition by washing freshly prepared samples of manganese dioxide with conductivity water. Trillat[3] claims to have prepared this sol by the oxidation of alkaline solutions of manganous salts under the protective influence of gum arabic, gelatine and dextrine. E. J. Cuy[4] has, however, observed that "he (Trillat) adduces no conclusive evidence to show that he was not dealing with complex copper tartarate and complex copper glycerate." Marck[5] obtained this sol from potassium permanganate solutions by using hydrogen peroxide, Spring and de Boeck with aqueous solutions and sodium sulphite, Deisy[6] with arsenious acid, Fremy[7] with sulphuric acid, Ganguly and Dhar[8] with manganous sulphate, Witzemann[9] with glucose, fructose and galactose, and Cuy by using aqueous ammonia. It should be observed that all these sols contain electrolytes produced during the formation of the sol. In nearly all

1 Gorgeu. *Ann. Chim. phys.* 1862. 66. 155

2 Spring & de Boeck. *Bull. Soc. Chim.* 1887. 48. 170

3 Trillat. *Bull. Soc. Chim.* Paris. 1904. 31. 811

4 E. J. Cuy. *Jour. Phys. Chem.* 1921. 25. 415

5 Marck. *Dissertation Heidelber* (1907); *Ann. Chim. Pharm.* 1867. 141. 205.

6 Deisz, *Koll. Zeitsch.* 1910. 6. 69; *ibid.*, 1914. 14. 139

7 Fremy. *Comptes Rendus.* 1876. 82. 475

8 Ganguly & Dhar. *Jour. Phys. Chem.* 1922. 26. 701

9 Witzemann. *Jour. Amer. Chem. Society.* 1915. 37. 1079

these cases, this electrolytic impurity would appear to be essential for the stability of the sol. Its removal by dialysis leads to the precipitation of the colloid on the parchment paper. An interesting method of preparing this sol in electrolyte-free condition was developed recently in these Laboratories,[10] viz., by charging the dialysing septum to a suitable negative potential.

The present communication records the results of experiments which were carried out with a view to examine if more concentrated sols could be prepared by using solutions of glycerol, gelatine, gum arabic, and sodium obate as protectives.

Using glycerol in small quantities, it was observed that its oxidation by $KMnO_4$ (as judged by decolorisation) was the main process, no colloid was formed. Use of increased proportions of $KMnO_4$ and ammonia gave but unstable sols.

The use of 1% gelatine solutions was next tried. As a result of a number of experiments it was found that sols of but low concentrations were obtained. Moreover, these sols coagulated in about 7 hours. Essentially similar results were obtained in a number of experiments with sodium obate solutions. These results are interesting in view of the well-known strength of gelatine and of sodium obate as proctective agents. Work now is in progress to investigate this apparent anomaly.

Use of gum arabic gave the most satisfactory results. With but traces of this substance dissolved in water and warmed with ·1N $KMnO_4$ solutions, sols were obtained which were markedly stable. These could be filtered and dialised without coagulation. This is contrary to results obtained with sols prepared by ordinary methods. The residual ammonia could be conveniently eliminated by boiling, which had no sensible effect on the stability of the sol.

Contrary to experience in previous cases it was found that when a dilute solution of egg white was used as a protector, a stable colloid could be produced from $KMnO_4$ without having recourse to

10 Joshi & Satyanarayanan. *Jour. Ind. Chem. Soc.* 1930, 7. 883

ammonia. Best results were obtained when the mixture was warmed and kept at 80° for a short period. The sol remained quite stable for a number of days. Moreover, contact with filter paper did not cause any precipitation. It was observed however that prolonged heating of the original mixture rendered the sol unstable.

প্রফুল্ল প্রশস্তি

হে চিরতরুণ দেশত্রাত গুরু, প্রজাহীন প্রজাপতি,
উজ্জ্বল করেছে মনোলোক, তব শত শত সন্ততি।
কণ্বের মত কুলপতি তুমি,
মুখর করিয়া তব তপোভূমি
তোমারি পালিতা বালিকা হইয়া বিহরে সরস্বতী।

জনসংহতি তোমারে বাঁধিতে পারে নাই কোন দিন,
তারই বেদনায় তবু যে তোমার নয়ন তন্দ্রাহীন।
ইহসংসার কোন প্রলোভনে
ধরিতে তোমায় পারেনি বাঁধনে,
সারা দেশই যার সংসার, র'বে কেমনে সে উদাসীন?

যোগীঋষি কভু দেখিনি, শুনেছি পুরাণকথায় আছে।
কল্পলোকের স্বপ্নযুগের জীব তারা মোর কাছে।
তোমা হ'তে তাঁরা ছিলেন মহান্
একথা কিছুতে মানেনাক প্রাণ।
ভয়ে ভয়ে বলি, সমাজের কাছে লাঞ্ছিত হই পাছে।

কার কথা কই? কত গৌরবই তোমারে রয়েছে ঘিরে,
সবার উপরে শিষ্যগরিমা দাঁড়ায় উচ্চ শিরে।
তোমার ধ্যানের শুচি আশ্রমে
উদ্ভাবনের কামধেনু ভ্রমে,
তোমার জ্ঞানের পরিবেশে দেশ অতীতে পেয়েছে ফিরে।

সত্যলোকের আহিতাগ্নিক তব তপোবনছায়,
মিথ্যামেধের মেধ্য অনল জ্বলে শত রসনায়।
পুড়িছে ভ্রান্ত আচার বিচার
সমাধি সেথায় সকল মিছার।
জাতির মুক্তি তাহারি মাঝারে পূর্ণাহুতিটি চায়।

আজিকে তোমার জন্মবাসরে নমি তোমা বাণীপূজারী
তব পাদযুগে এই শুভযোগে হৃদয়ের ডালা উজাড়ি।
কায়মনোবাকে শুভসংহতি
তোমার মাঝারে ধরেছে মুরতি,
তোমার জীবনে ত্যাগভাস্বর প্রাচীন ভারতে নেহারি।

তোমার মুখের জ্ঞানভূয়িষ্ঠ রসঘন মধুভাষণা
শুনিবার লাগি ছাত্রজীবনে ফিরে যেতে হয় বাসনা।
মানসসরসী করিয়া শোভন
তোমার সুরভি শুচি ও জীবন,
পঙ্কিল দেশমর্ম্মমৃণালে ফুটিল সুষমা বিথারি।

নবীন বঙ্গ যাত্রা করেছে তব শুভাশিষ বহিয়া
তোমারি মতন করি প্রাণপণ কৃচ্ছ্রসাধন সহিয়া।
তাহার বিজয়ে তোমারি বিজয়,
তুমি যার গুরু তাহার কি ভয়?
চলে সে তীর্থে তোমারি শেখানো "সত্যের জয়" ফুকারি'।

নব নালন্দা তব চারিপাশে আবার লভেছে স্ফূর্ত্তি,
তোমার মাঝারে নাগার্জ্জুনের ব্রত ধরিয়াছে মূর্ত্তি।
সপ্তভিদলে লভিল যা জয়
শতদলে যেন পূর্ণ তা হয়,
এই নিবেদন লয়ে অনুখন বিভুপদে মোরা ভিখারী।

শ্রীকালিদাস রায়

The Environmental Control of Population Movement in Northern India

By Radhakamal Mukerjee (Lucknow).

The distribution of plants and animals is governed very largely by temperature and rainfall. We hardly realise the extent to which the environment similarly controls the distribution of mankind. We have dense populations where natural conditions are most congenial to man and the necessaries of life most easily obtained. The most heavily populated parts of the world are the hot monsoon lands of Asia and the lowland plains of the temperate lands. The hot region of south-east Asia enjoys the unique advantage of an abundant rainfall during summer which is most conducive to vegetable growth. Thus this region is wonderfully productive and most heavily populated in the world.

There are two sub-regions where population is densest. These are the densely populated plains of China and of India where the monsoon rainfall as well as the alluvial silt from the mighty rivers are responsible for a marvellous agricultural productivity. The four more densely peopled provinces of China are as follows :—

	Density of population per sq. mile.
Kiamgsu	875
Chekiang	600
Shantung	500
Honan	454

The provinces of China generally have been considered so far as the most heavily populated regions in the world. The estimates of population given above represent the most scientific and probably the most reliable computation of the population of

China that has yet been made. These, however, indicate that the palm of credit for being the most densely peopled region in the world must go to the Indo-Gangetic plain where in some natural entities we reach the phenomenal figures of 1,000 to 3,000 persons per sq. mile. In the three regions—the Northern, the Yangtse Delta, and the Canton Delta—the density of population does not exceed 1,000 to the sq. mile. Similarly, in the Plain of Chengtu, the scene of the most intensive irrigation in China, the density of population according to one careful estimate, does not rise beyond 1,700 to the sq. mile. But in the Ganges Plain the density in some rural areas reaches incredible figures of 3,000 and over. Two strips of territory in Mymensingh joining together in the south-western part of Dacca and continuing in a southerly direction through the alluvial tracts of Faridpur and Bakarganj constitute a block in which the population is in no area less than 1050 and reaches as much as 2,200 per sq. mile.

There is another striking difference in the distribution of population in the plains of China and of India. In China the plains are very varied from the point of view of soil conditions and habitability. Thus the density is very unequally distributed. The Ganges Plain, on the other hand, is densely populated throughout. As we move further and further towards the deltas, the soil and climate become more and more favourable to agriculture and rural density and we have in the deltaic districts the world's highest records of concentration of population along the water-ways.

Now the concentration of population bears very close agreement with certain universal principles derived from geography and ecology. These, indeed, suggest how much ecology and geography have to offer economics towards the interpretation of the distribution of population. Ecology is the science of the adjustment of living creatures to the environment. Now the dependence of living creatures upon climate and other physical conditions is the greatest where the natural environment is most unfavourable and where the multiplication of numbers has made the struggle for existence most acute. Fortunately for us a survey of the Gangetic Plain and of its borderlands affords the

most favourable opportunity of studying at once the effects of the most favourable and the most unfavourable conditions of life upon the density of populaton.

Desert and Density

On the fringes of the most fertile valley of the world we have the Great Desert. It is in the environment of the desert that one can clearly observe than elsewhere the interaction of plant and animal upon each other and the dependence of all living creatures upon climate and other physical conditions. In the desert we have the closest adjustments of living creatures to the component elements of the environment. The most remarkable examples of physiological adaptations arise, for instance, from adjustments to scantiness of water. Most animals of the desert require little water. Camels have been known to go two months without drinking. Subterranean rodents find moisture in the bulbs and roots of perennial plants, and the sparse but succulent, thick-leaved growths, characteristic of the desert's surface, are often miniature reservoirs. Experiments carried out by Buxton have shown that even the dry fragments of vegetation blown about by the winds contain moisture upon which insects and small animals may thrive. These dry stalks are capable of absorbing water directly from the atmosphere when, as is often the case in the desert at night, the relative humidity rises above 80. Many of the animals of the desert avoid the intense heat of the daytime by burrowing to cool, moist depths and die when exposed to the sunlight or superheated sand, rock or gravel of the surface.

The desert is as hostile to man as it is to animals and plants. Normal agriculture is impossible in the desert and man's life is a constant struggle for mere existence in the face of extremes of cold and heat with the menace of drought and famine ever at hand and of such aberrations of the climate such as long droughts, torrential rains, unusual frosts, and violent whirlwinds. The marked seasonal changes breed the nomad. The nomad is wholly dependent upon the flocks, around the preservation of which the entire course of his life revolves. North-west of the Aravalli

range in Rajputana, south of the Plains of Northern India, there is a vast dry area, with a rainfall generally less than 10 inches annually, which slopes gradually towards the Indus Valley and the Punjab Plain. This forms the Thar or Great Indian Desert. It consists of a sandy waste interrupted by hills and waterless valleys. The ground is often entirely bare. Here and there grow a few desert shrubs and plants. Jaisalmer lies in the centre of the Thar with a mean rainfall of only 6·7 inches and is a barren desert. The people here are very greatly nomadic depending on their herds of cattle, sheep and goats. Out of a population of 88,311 the number which is supported in this way comes to 19,810. Throughout Rajputana population is sparsely distributed and the dictum holds good that a scanty rainfall means a scanty population. In the Western division, which embraces the Great and Little deserts of India, the normal rainfall varies from 7 to 13 inches. Even this amount is very capricious and falls mainly during storms. Here the density of population is only 59 per sq. mile. This sparse population can be maintained with difficulty on account of the extraordinary variability and local character of the rainfall. Thus famine is recurrent in the dry grass lands. An ancient couplet speaks of this dread monster thus:

"His feet are in Punjab
His head is in Merta
His belly's in Bikaner
In forgetful moments,
He 'ill visit Jodhpur,
But he is always in Jaisalmer."

The soil here is often fertile, and if irrigated would no doubt, in some parts at least, be capable of supporting as great a population as the canal colonies of the Punjab. But there is at present no irrigation as there are no large rivers which can be used for this purpose. Even if rivers existed, irrigation would have been difficult as the land is uneven and irregular. In the decade 1891-1901 which was one of disastrous famines, the population in the Western division showed a heavy decrease of 25·4 per cent where the variations in rainfall are most critical. The whole tract necessarily is

subject to marked fluctuations in migration. A considerable portion of the population is, as we have seen, of the nomadic sort, which moves backwards and forwards with its herds at the first signs of failure of rain, or crops or fodder. Villages spring up only where a little water is available and millet and fodder can be grown. Often, however, the water in the wells fails or becomes brackish and then the village has to be abandoned.

It is a curious fact that in the Indian desert we find a striking disparity between the proportions of the sexes. In most of the Rajputana states and districts the proportion of women in their actual populations is low; in Jaisalmer the ratio is the lowest, there being only 820 females to 1,000 males. A theory has been put forward that the ratio of females to males is depressed by a dry and hot climate, particularly if accompanied by a considerable range of temperature. One effect of the rigorous environment no doubt, has been that in the Western Division in Rajputana, which is the driest and hottest, there is less inclination among men to take upon themselves the bondage of wedlock than elsewhere. The proportion of bachelors over the age of 15 is highest here. This tendency to celebacy is most marked in Jaisalmer state where nearly half of the males between 20 and 40 remain unmarried. At the same time it seems extraordinary that the state with the lowest proportion of females also shows almost the greatest tendency to polygamy. It is clear that both the hostile environment and the roving fluctuating life of the people have produced such aberrations. Nothing can illustrate better the control of man by the environment.

South-east of the Indian desert there is the hilly, mountainous plateau or Rajput Upland region which embraces a number of native states most of which played an important part in the history of Imperial Delhi. Sandy wastes extend from here towards the north and the north-east and here and there may be found the vestiges of rivers which have lost themselves in the sands, and of cities which have been sand-buried. The region receives less than 25 inches of rain and passes gradually to the Ganges Doab where the normal rainfall is nearly 30 inches and hot winds blow

in summer. Here we have the economic and climatic frontier separating grazing country from cultivated plains. This often corresponds approximately to the twenty inch rainfall line. The deficiency of rainfall here is not as serious in its effects upon the wild grasses of the pastoral country as upon the crops of the cultivated region. But when the rainfall is deficient over wide areas the drought limits extend to parts of the Doab, fringing the arid regions of the interior. The Doab is also a hot and dry region, like the Rajput Upland region, but while the latter is hilly and makes irrigation difficult, the former is one great plain sloping very gently from Delhi (700 feet) to Allahabad (400 feet). The rainfall gradually increases as we travel down the Doab and we can take the confluence of the rivers, through which the 40 inch rainfall line passes, as the eastern limit of the dry region of the Upper Ganges Plain.

The Ganges Doab and Intensive Farming

The Upper Ganges Plain is now intersected by canals and its agriculture has been revolutionised. The region is extensively cultivated and there has been an enormous concentration of human and cattle population. As we proceed along the course of the Ganges farther there is more rain and a smaller range of temperature. Irrigation is also less difficult. The subsoil in many parts of the Doab especially towards the east is peculiarly favourable for well construction. In the Rajput Upland region the staple food is millet; in the Upper Ganges Plain wheat is introduced by canal irrigation though millet also forms a very important crop, second in importance only to wheat; in the Middle Ganges Plain, the wet region crop, rice becomes more important than wheat, and supports a heavy population. An abundant rainfall in summer, a high and equable temperature, an annual inundation by the rivers carrying rich detritus from the Himalayas, an arranged succession of leguminous crops along with rice,—all these have contributed to make the Ganges Valley the most productive in the world. But man by his multiplication even in the most fertile valley has increased his struggle for livelihood to such an extent that the

slightest disturbance of the natural conditions of agriculture produce violent reactions upon his standard of living and even his numbers. Throughout the Ganges Plain the incidence of the density of population bears a close correspondence with the percentages of the net cultivated and the double cropped area to cultivable area. This will be clearly evident from the statistics of population, agriculture and water supply of the typical districts in the different natural areas of the United Provinces:

Name of District (arranged according to natural regions)	Normal Rainfall.	Net cultivated to cultivable area.	Percentage of Irrigated to irrigable area.	Area cropped more than once to total cultivated area.	Density of Population. Rural Density in parenthesis.
Gangetic Plain, West.					
Meerut	28·09	82·4	36·8	33·4	652 (545)
Bulandshar	26·0	80·5	49·8	31·7	560
Aligarh	25·0	79·9	60·2	21·5	545 (456)
Muttra	23·6	82·5	40·3	12·5	427 (350)
Gangetic Plain, Central.					
Cawnpore	31·8	75·3	44·7	9·4	485 (392)
Unao	33·4	69·3	44·0	18·7	458
Partabgarh	37·9	74·3	53·7	28·0	592
Gangetic Plain East.					
Benares	39·9	82·6	68·2	22·8	898 (704)
Jaunpur	40·6	76·0	71·2	25·6	745 (711)
Azamgarh	40·4	77·3	79·9	26·2	690
Ballia	41·4	78 8	5·6	24·6	679

Table I.

A limit seems to have been reached in the major portion of the plain in the direction of extensive farming. Most of the districts in the Western, Central and Eastern portions of the Ganges Plain have reached more than 75 per cent of net cultivated to cultivable area. Thus more and more the proportion of double-cropped area, i.e., the quality of intensive farming governs the increase of the density of population.

Now that the population is out-reaching the means of subsistence in the Upper Ganges Valley is indicated by the fact that the density of pouplation district by district increases at a greater rate than the proportion of land which is cultivated and the proportion of area cropped more than once.

Name of District (in the Upper Ganges Valley).	Percentage of increase of total cropped area. 1891-1924	Percentage of increase of density. 1891-1921
Saharanpur	2·0	·10
Muzaffarnagar	5·5	3·6
Meerut	1·6	10·1
Bulandshahr	4·1	12·9

This implies that there is a keener struggle for existence and a tendency towards a lower standard of living.

The Dry Steppe

The effect is, however, most apparent in those parts of the valley, where the water supply, which is the life of agriculture, is naturally deficient or exposed to violent seasonal fluctuations. Such effects will also be found to operate over more or less contiguous blocks, that is, natural entities, where the temperature and water supply bring about a similarity of geographical and other physical characteristics. We find that the South-western portion of the Ganges-Jumna Doab which fringes the semi-arid tract bordering the Great Desert has shown a decrease of density within the last three decades. It is most interesting to note that in the dry steppe tract of this province where the 'index of aridity' is below 22 or 23, the artificial protection of agriculture by the upper and more reliable portions of the Ganges and Jumna Canals could not keep up the increase of population of the earlier period.*

* Martonne's index of aridity $= \frac{\text{Annual Precipitation (millimetres)}}{\text{Mean Annual Temperature in degrees Centigrade} + 10}$,

	District.	Index of aridity.	1865	1872	1881	1891	1901	1911	1921	Actual decrease in mean density between 1901-1921
Dry Steppe	Muttra	15·5	498	551	463	492	526	452	427	−99
	Aligarh	17·0	498	547	525	536	617	599	546	−71
	Agra	17·0	533	575	525	541	572	551	498	−74
	Etah	18·2	437	465	438	406	500	504	483	−17
Prairie	Jalaun		262	260	270	256	258	261	262	
	Mainpuri	21·2	420	452	478	455	495	476	447	−48
	Etawah	21·5	384	395	427	430	477	449	434	−33
	Cawnpore	22·9	504	495	498	510	531	482	485	−46
	Unao	19·5	537	554	503	534	546	510	458	−88
	Bulandshahr	21(?)	420	490	485	498	597	590	562	−35
	Meerut	21·2	513	541	560	593	657	648	653	−4
	Muzaffarnagar	22·0	414	416	453	462	524	483	479	−45

Table II.

Percentage variations of total cropped area and density between the period 1891-1921.

	Total cropped area.	Density.
Meerut	11·25	10·12
Muttra	−3·33	−13·24
Aligarh	−1·71	1·86
Agra	4·35	−7·95

Of all areas in the United Provinces the districts of Aligarh, Muttra, Agra and Jalaun exhibit the largest fluctuations of cropped areas from year to year; such fluctuations being the greatest in bad rainfall years. It is also noteworthy that the canal-irrigated districts follow the 'unprotected districts closely as regards the variations of cropped area. This indicates that canal irrigation can assure no better certainty of crops under the conditions of a precarious rainfall than is available for the unprotected districts. This is mainly due to the increase of total cropped area as a result of the pressure of population so that the amount of water which may be supplied by the canals is inadequate in years of unfavourable rainfall. A large amount of reclaimed land is also unsuitable for irrigation. In these particular districts the shrinkage of cultivated area and decrease of population density seem to go together, giving evidence of a losing battle with unfavourable hydrographical conditions.

Professor Pearl laid down the demographic law that when population density reaches an equilibrium point, the death-rate exceeds the birth-rate, and we have a decline of population until the equilibrium is restored. We have an interesting corroboration of Prof. Pearl's principle from some areas of the Ganges Plain. It would appear from the movement of birth and death rates of Muttra, Agra, Aligarh, Etawah etc. that mortality tends to be increasingly higher than natality. Of course different districts would reach the saturation density in different decades due to different conditions of agricultural water supply and thus the decrease of population density has not been uniform. Such decrease of density has been seen with or without a shrinkage of the total area cropped in the district.*

* Mukerjee: Population Balance and Optimum, *Proceedings of the International Population Congress*, Rome, 1932.

The Eastern Districts of the United Provinces

The Eastern districts which enjoy a more reliable rainfall than those of the South and West multiplied in such large numbers that their position has also become equally precarious so far as the maintenance of the present standard of living and even of numbers is concerned. In their cases too density of population primarily depends upon the proportion of land which is cropped more than once, the percentage of net-cultivated area having reached nearly 80 per cent of the cultivable area. Notwithstanding the excellent and timely insurance against the distress of a famine which these districts provide by an extended system of well-irrigation and which explains much smaller shrinkages of cropped areas in famine years than in the South and West, the density of population here also shows a tendency to decrease. This is shown in the following table (Table III).

The Table shows no doubt a steady tendency towards expansion of total area cropped, but the expansion of population density is disproportionately large in the cases of newer districts like Gorakhpur and Basti. This will be evident from the following figures—

	1881	1891	1901	1911	1921
Gorakhpur	574	657	649	707	722
Basti	582	637	659	653	687
Benares	885	914	875	890	899
Azamgarh	733	790	700	675	691
Jaunpur	780	816	776	746	745

If Benares, Azamgarh and Jaunpur show a decline in their density of population from 1891, inspite of a steady extension in the total area cropped (including area cropped more than once) and an extension of well-irrigation which in years of drought have reached the phenomenal figures of 95, 93 and 82 per cent respectively to estimated irrigable area, does it not support the inference that due to the enormous pressure of population on the land man's efforts are here showing a diminishing return, and population is reaching a set-back?

Districts.	Percentage of area cropped more than once to total cultivated area.	Percentage of well-irrigated to total irrigable area in the last famine year 1918-1919	Density of population.	Percentage of increase of total net-cropped area including area cropped more than once 1892-1920	Percentage variations of density 1891-1901	1901-1911	1911-1921	1891-1921
Gorakhpur	32·8	52	721	+2·4	− 1·2	8·9	2·1	9
Basti	37·3	34	687	+ 5·4	3·4	·9	5·2	+ 8
Azamgarh	26·2	57	690	+ 9·7	−11·4	− 3·6	2·4	−13
Jaunpur	25·6	86	745	+ 1·3	− 4·9	− 3·9	− ·1	− 9
Benares	22·8	92	898	+10·7	− 4·3	+ 1·7	1·8	− 2
Ballia	24·6	55	679	+ 5·6	− ·8	−14·4	−1·7	−15
Ghazipur	16·9	45	597	− 8·3	−10·8	− 8·1	− ·9	−19

Table III.

It is only the districts north of the Ghagra which are naturally protected by a heavy and reliable rainfall and where irrigation is easy on account of the high water level that are still maintaining an increase of population. During the thirty years, 1891-1921, the density of population in Gorakhpur and Basti has increased four and two-half times more than the total net-cropped area (including area cropped more than once). Obviously the very multiplication of population will sooner or later bring them into a line with the Southern and Eastern districts where the phenomenon of decrease of population and a lowering of the standard of living would not have been experienced under favourable conditions of soil and water supply but for redundancy of mouths to feed.

It is in this manner that we realise that if we take several decades, the effects of variations caused by disease such as plague, malaria and influenza might be minimised, and the variations would reflect permanent tendencies. A tendency towards a shrinkage of population has appeared even in the most favoured area of the world. Towards the South and the West of the Plain this has been due predominantly to arid conditions and to famine which these imply in years of a deficient or irregular rainfall. In the middle and eastern portions this shrinkage simply indicates that the optimum density of population has been overstepped, thus the least variation of the amount and distribution of rainfall which would not have had any effect if these portions were less heavily populated, now has violent reactions.

Density in Bihar

These reactions on man's numbers and his standard of living are visible also in Bihar and these diminish in their potency as we reach Bengal.

In Bihar the symptoms of over-population are also clearly visible. A succession of good harvests is followed as in the United Provinces by an increase in the number of births and gradual fall of mortality· When the harvests are short and the price of food grains rules high, the birth rate rapidly declines and the mortality rises. This will be evident from the accompanying table (Table IV).

Relation between agriculture and public health.

Birth and Death-rates during unfavourable years in North and South Bihar.

	1906		1907		1908		1912		1914		1915		1918		Average of two decades 1901-1920	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
NORTH BIHAR.																
Birth rate	40	36	37	33	42	38	45	41	43	39	43	38	40	35	42	37·5
Death rate	41	35	37	34	35	31	37	32	30	27	35	31	60	52	38	33
Survival rate	− 1	+ 1		− 1	+ 7	+ 7	+ 8	+ 9	+13	+12	+ 8	+ 7	−20	−17	+ 4	+ 4·5
SOUTH BIHAR.																
Birth rate	45	41	46	42	41	37	48	44	47	43	46	43	42	38	44·5	40·5
Death rate	44	40	44	42	43	39	33	31	32	32	34	33	70	69	41·0	39·0
Survival rate	+ 1	+ 1	+ 2		− 2	− 2	+15	+13	+15	+11	+12	+10	−28	−31	+ 3·5	+ 1·5

Table IV.

Throughout a large portion of Bihar the volume of emigration also corresponds to the state of the harvests. If the harvests are good, the emigration diminishes, if they are bad it is larger and lasts longer. The close adjustment of human numbers to the food supply is clearly shown not only by such phenomena but also by the correspondence between rural density and the percentages of double-cropped area to total cultivated area, the latter assuming a phenomenal figure district by district.

District and Natural Area.	Percentage to cultivable area of Net cultivated	Double cropped	Percentage Variation of total area cropped (including area cropped more than once) between 1891-1921	Density. 1891	1901	1911	1921	Variation of Density 1891-1921.
NORTH BIHAR.								
Muzaffarpur	81·5	55·3	+15·8	894	908	937	907	13
Saran	72·6	44·4	+10·0	909	898	853	872	−37
Darbhanga	85·7	31·2	+ 5·37	837	870	875	870	33
Bhagalpur	64·7	22·8	− 12·0	481	494	506	481	−25
Purnea	59·9	11·6	+ 8·7	390	376	398	405	15
SOUTH BIHAR.								
Patna	64·7	29·0	− 1·6	857	785	778	763	−15
Shahabad	76·4	16·1	+11·2	471	449	427	415	−12
Monghyr	73·4	21·6	+10·7	519	527	544	517	−27

Table V.

The above table shows that the density of population depends upon the proportion of land which is cultivated and upon the proportion of double-cropped area, and that the density of population increases at a greater rate than these proportions. This indicates that the law of diminishing returns is operating. Indeed the slightest disturbance of agriculture brings about conditions of famine and scarcity in a large portion of heavily populated North Bihar.

The net cultivated areas between 1891-1921 show enormous fluctuations in Bihar districts. This indicates a more precarious agriculture than that of the eastern districts in the United Provinces, for instance, where the climate and rainfall are similar to Bihar. The difference is due solely to the fact that wells that have proved a useful and valuable resource in bad rainfall years in the United Provinces do not exist in such large numbers in Bihar. It is noteworthy that Bhagalpur, which shows most violent oscillations and a tendency towards permanent shrinkage of cultivated area is least equipped with the well system of irrigation, and yet most dependent upon rainfall for her early monsoon crop.

All the more heavily populated districts in Bihar now exhibit a tendency towards stationary condition or even decline in the density of population : the cultivated area shows violent fluctuations and the precariousness of agriculture has already left its impress upon declining numbers.

The Moribund and the Active Delta

As we proceed further and reach Eastern Bengal, such reactions cease. The unique advantages of water supply which the deltaic peasant enjoys can maintain so far a high standard of living inspite of multiplication. Yet even in the deltas the concentration of population along the waterways continues in such pace that the optimum will be over-reached in a few decades more.

In the lower Ganges Valley, the disparity of economic progress between the moribund delta of the Ganges and the active joint delta of the Ganges and Brahmaputra rivers, where the fertility of the soil is replenished yearly by deposits of silt, will be evident

District and Natural Area.	Percentage of cultivated area to net	Double cultivated crop.	Percentage Variation of total area cropped (including area cropped more than once) between 1891-1921	Density 1891	1901	1911	1921	1931
MORIBUND DELTA.								
Burdwan	54·0	15·5	−34·9	517	570	572	532	583
Hooghly	62·3	2·5	−55·7	870	883	918	909	938
Murshidabad	44·5	15·2	−42·9	584	622	640	595	656
Midnapur	78·1	3·1	− 5·5	507	538	544	528	534
Nadia	44·7	17·1	−15·7	586	594	580	535	531
Jessore	85·4	4·3	−21·8	646	620	601	593	576
ACTIVE DELTA.								
Bakarganj	88·3	14·7	+39·5	616	656	695	752	834
Faridpur	97·9	14·8	+16·8	785	833	905	949	1003
Dacca	94·0	20·0	+21·6	861	952	1066	1148	1256
Mymensingh	86·5	26·2	+ 3·1	556	627	724	776	823
Noakhali	87·0	31·9	+ 9·3	614	694	792	972	1,124
Tippera	93·3	40·2	−14·4	713	848	972	1072	,197

Table VI.

even from a casual survey of the figures of density of population and net cultivated area. As in Bihar and the United Provinces, we find a correlation between double-cropping and density of population. The districts in the moribund deltaic area in Bengal show much smaller percentages of both net-cropped and twice cropped areas and rural densities than those in the active delta. Both agriculture and population in Western Bengal have received a set-back due to the cessation of the delta-building functions of the Ganges and her tributaries. The population of Bengal rose by 33 per cent between the years 1872 and 1901; between 1911 and 1921 by 2·8 per cent and between 1921 and 1931 by 7·3 only. There have been local instances of crop failure,

but nowhere in India has famine played such an insignificant part in the variation of population. Yet the population hardly maintains its natural rate of increase.

The deltas are so favourably situated that we do not expect any deficiency or irregularity of rainfall, which causes famine in the central and western portions of the valley. But all deltas are fluctuating geographical entities. In one portion of the delta the beds of the rivers are gradually raised by the annual deposit of silt and some rivers are silted up. The banks of the rivers being raised gradually above the surrounding country by the accumulations of silt, swampy depressions arise. Whole areas become water-logged and sometimes thrown out of cultivation. The climate becomes unhealthy and fever becomes rife. The natural coming of age of the delta produces serious effects on agriculture and health but these have been intensified by the building of roads, railways and embankments. Thus deterioration has sent in in areas in Nadia, Jessore and Murshidabad, and to a less extent in Howrah and Hooghly. The Bhagirathi and the Damodar embankments are to a large extent responsible for the decline of Murshidabad, Nadia and Jessore and Howrah and Hooghly respectively. Instead of the gradual rise of the surrounding region by the natural deposit of silt, only the areas bordering the rivers are being raised due to successive floods. Thus the *aman* rice cannot grow as the land is too high for it, yet the lack of adequate high land leads to the digging of tanks when house sites are made. On account of the outward thurst of the population from the upper and middle portions of the Ganges Valley, the delta has become populated earlier before its time, and is to a large extent responsible for the decline of present rivers, of agriculture and human numbers. As the population has become thick, the struggle for existence is keen, and the slow and gradual loss of resistance which malaria bring about leads to increased mortality due to epidemics and a general lowering of birth-rate. Thus some of the districts in the moribund portion of the delta have already begun to show a decrease of populntion and also a relative increase of death-rate over birth-rates. In Eastern Bengal, many districts have now considerably a large margin for an expansion of population. The density of

rural population can still increase and the soil can bear the increase easily. But a stage will sooner or later be reached when the capacity of agriculture will be overstepped.

The following table which compares the distribution of land in the natural regions of Bengal clearly shows that population is already pressing heavily on the cultivated area in Eastern Bengal. The percentages of cultivable waste and current fallow in Eastern Bengal are extraordinarily small.

	Percentage cultivable area cultivated.	Percentage cultivable waste	Percentage current fallow.
Eastern Bengal	90	7	3
Northern Bengal	71	14	5
Western Bengal	61	26	12
Central Bengal	58	18	24

Fertility and Fecundity

This will be more evident if we compare such percentages district by district with the proportions of double-cropped area.

	Percentage of net cultivated area to total area.	Percentage of cultivable waste to net-cropped area.	Percentage of double-cropped to cultivable area	Percentage of current fallow to net-cropped area.
Faridpur	85·7	9·5	14·8	4·0
Bakarganj	81·1	11·6	14·7	1·6
Dacca	75·3	2·7	20·1	3·9
Mymensingh	61·5	11·5	4·1	2·5
Burdwan	44·6	24·5	15·5	45·0
Hooghly	66·5	17·5	2·5	34·9
Nadia	35·3	40·4	17·1	54·6
Murshidabad	39·6	46·0	15·2	64·6

Table VII.

Of the 8 per cent of land, cultivable but not cultivated in Dacca, the most congested district in Eastern Bengal, 4 per cent is used for growing reeds, bamboos and thatching grass, leaving only 4 per cent of the total cultivable area as fallow and capable of cultivation. Thus 1 acre in 25 acres of land capable of bearing crops is left fallow every year. The actual current fallow in the

whole district is only 14 sq. miles. This implies that a period of 156 years is required until every acre has been relieved of its burden of bearing its one or two annual crops. Considering the extraordinary small rest given to the land it is surprising to see yet a further effect of the pressure on the soil in the fact that no less than 35 per cent of the cultivated area is made to bear two or more crops a year.*

The agricultural statistics of those districts which show the highest population density in Bengal, Bihar and the United Provinces respectively may be compared (Table VIII).

The burden of heavy cropping year in and year out for a very thick population can only be borne in Dacca because of the annual flush and inundation by the silt-laden rivers. Yet in a few localities, which are remote from the active rivers or situated on old raised land or water-logged, marks of agricultural deterioration are clearly in evidence. The population here has already started on the path, or is now on the verge, of decline. Indeed, the check on expansion of population commenced in the area farthest up the alluvial bed of the Padma, and the effects are gradually spreading fan-like from this point. The river has succeeded in raising these areas to such an extent as to destroy the internal water system, to stop the natural flushing of the area, to leave it water-logged and to create on the fringes of the water-logged area a breeding ground for malaria. Thus higher mortality from disease like malaria, cholera and small-pox in these decadent areas is the surest proof of the guilt of river action, of a crime of Nature, which operates slowly but inevitably in all deltaic tracts. But it is considered probable that the next census will show a general decrease in population in the area, though it is unlikely that the affected area will spread with any rapidity. Inspite of the elaborate rotation of crops and the cultivation of a heavy yielding monopoly crop like jute which the deltaic conditions have encouraged, the pressure of population on the land will similarly be felt elsewhere in Eastern Bengal if this phenomenal expansion of population

* Ascoli : Dacca Survey and Settlement Report

	Density of Population	Percentage of cultivated area to cultivable area.		Percentage of twice-cropped area to cultivated area.			Normal Rainfall.		Percentage of gross cultivated area which is irrigated.	
	1931	1921	1931	1921	1931	1921	1931	1921	1931	1921
Benares	931	898	83·4	82·6	20·3	22·8	40	46·4	26·6	31·1
Muzaffarpur	969	907	82·2	92	64·8	46	45·75	40	12·5	11·4
Dacca	1265	1,148	94·8	92	18·6	35	74·3	74·72	×	×

Table VIII.

continues unabated. Thus the contrast that districts in Eastern Bengal are still increasing their population while some in Western Bengal with a population half as dense have remained stationary or decreased will slowly disappear and the higher standard of living of the cultivator in Eastern Bengal will be brought into a level with that of the ill-fed and under-clothed peasant of Bihar and West Bengal districts. Famine also will make its appearance, not caused by the fluctuations of rainfall but by the fluctuations of the rivers as in the alluvial plains of China, and later on, when the river-basins attain a more advanced stage of development. It is a paradox that man suffers from scarcity or famine in a fertile valley richly endowed by Nature, but the paradox is explained by the fact that where man is improvident, even the most bountiful resources which are Nature's gifts fail him. To Nature's gifts of favourable rainfall and inexhaustible fertility, man might add his own contributions, such as artificial irrigation, and intensive farming or the cultivation of non-food crops which command a profitable market abroad, but if he commits crime against his generation neither Nature's blessings nor his own efforts may be of any avail. Not until the fundamental laws of population are understood by the general masses poverty will continue in the midst of plenty, and the struggle for food bring about the same ecologic adjustment as is witnessed in a rigorous and hostile environment.

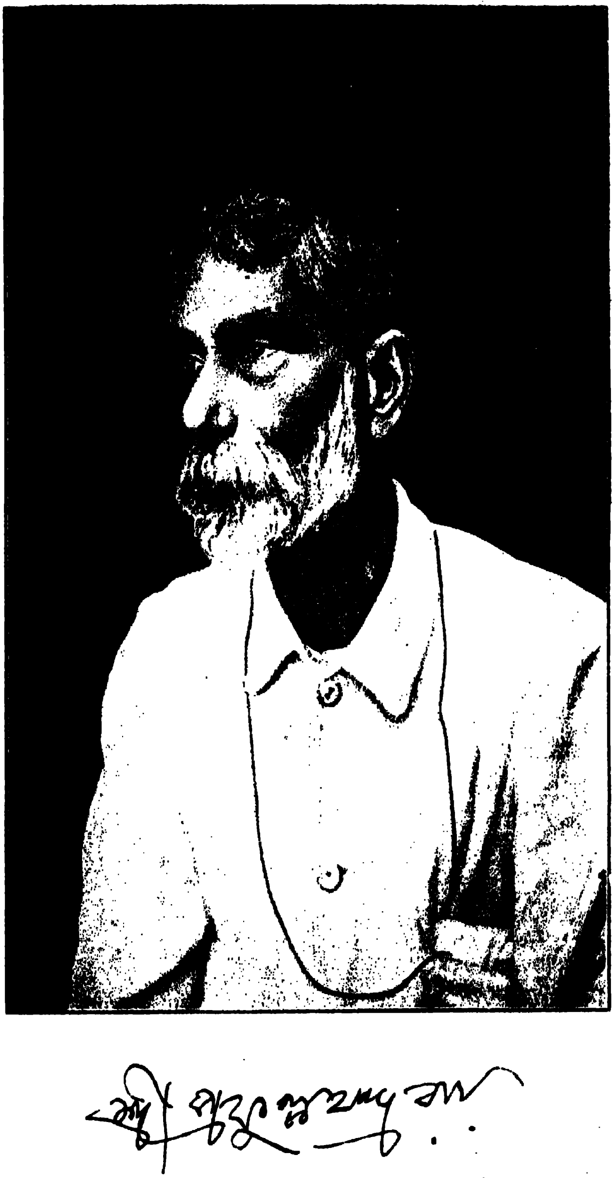
অধ্যাপক প্রফুল্লচন্দ্র রায়

প্রায় ৩৫ বৎসর পূর্ব্বে "প্রদীপ" পত্রে শ্রীযুক্ত প্রফুল্লচন্দ্র রায় মহাশয়ের সম্বন্ধে আমি একটি প্রবন্ধ লিখি। এই কাগজ অনেক বৎসর হইল উঠিয়া গিয়াছে; পুরাতন "প্রদীপ" দুষ্প্রাপ্য হইয়াছে। আমার পূর্ব্বে লিখিত প্রবন্ধটি আচার্য্য রায়ের স্মারকগ্রন্থে প্রকাশ করা সঙ্গত মনে করি।

শ্রীযুক্ত প্রফুল্লচন্দ্র রায় ১৮৬১ খৃষ্টাব্দে খুলনা জেলার অন্তর্গত রাড়ুলী গ্রামে এক সম্ভ্রান্ত ও সম্পন্ন কায়স্থ পরিবারে জন্মগ্রহণ করেন। এই গ্রাম অমর কবি মধুসূদনের জন্মগ্রাম সাগরদাঁড়ি হইতে ৮ মাইল দূরে কপোতাক্ষ নদের কূলে অবস্থিত। মধুসূদন এই কপোতাক্ষকেই উদ্দেশ করিয়া সুদূর ফরাসী দেশ হইতে লিখিয়াছিলেন :—

"সতত হে নদ, তুমি পড় মোর মনে।
সতত তোমার কথা ভাবি এ বিরলে;
সতত (যেমতি লোক নিশার স্বপনে
শোনে মায়ামন্ত্রধ্বনি) তব কলকলে
জুড়াই এ কাণ আমি ভ্রান্তির ছলনে।
বহু দেশে দেখিয়াছি বহু নদদলে
কিন্তু এ স্নেহের তৃষা মিটে কার জলে?
দুগ্ধস্রোতোরূপী তুমি জন্মভূমি স্তনে।"

প্রফুল্লচন্দ্রের পিতা ৺হরিশ্চন্দ্র রায় কৃষ্ণনগর কলেজে কাপ্তেন ডি, এল, রিচার্ডসনের নিকট ইংরাজী শিক্ষা করেন। তিনি আরবী ও পারসী ভাষাতেও ব্যুৎপন্ন ছিলেন। বঙ্গসাহিত্যে তাঁহার একান্ত অনুরাগ ছিল। ঈশ্বরচন্দ্র বিদ্যাসাগর, অক্ষয়কুমার দত্ত, মধুসূদন দত্ত, দ্বারকানাথ বিদ্যাভূষণ প্রভৃতি সুলেখকগণের বন্ধুর বঙ্গসাহিত্যানুরাগী হইবারই কথা। প্রথমোক্ত দুই মহাত্মার সংসর্গে পড়িয়া তিনি সর্ব্ববিধ সমাজিক সংস্কারের পক্ষপাতী হন। তিনি বার্ষিক ৪।৫ হাজার টাকা আয়ের পৈত্রিক সম্পত্তির অধিকারী ছিলেন। তিনি চাকরী কখনও করেন নাই, করিতে ইচ্ছাও করেন নাই। নিজ গ্রামে নিজ ব্যয়ে একটি বিদ্যালয় স্থাপন পূর্ব্বক প্রায় ২৫ বৎসর উহা চালাইয়াছিলেন। এই বিদ্যালয়ের জন্য তাঁহার মাসে ৪০।৫০৲ টাকা



The Indian Photo Engraving Co., Cal.

By Courtesy of the Prakriti.

ব্যয় হইত, সরকারী সাহায্য হইতে অবশিষ্ট ব্যয় নির্ব্বাহ হইত। উহাতে প্রথমে মধ্যবাঙ্গালা, পরে মধ্যইংরাজী, ছাত্রবৃত্তি পরীক্ষা পর্য্যন্ত পঁড়ান হইত। তিনি স্বগ্রামে একটি বালিকাবিদ্যালয়ও স্থাপন করেন। তিনি অনেক ধনী ও বিলাসী লোকের সঙ্গে মিশিতেন, তাঁহাদের অনেকের চরিত্র বড় ভাল ছিল না। কিন্তু হরিশচন্দ্র আজীবন পবিত্রচরিত্র ছিলেন। তিনি পরিচ্ছদ সম্বন্ধে বড় উদাসীন ছিলেন। এ বিষয়ে প্রফুল্লচন্দ্র "বাপ্‌কা বেটা" a chip of the old block. তিনি নিজ সন্তানগণকে সকল বিষয়ে সম্পূর্ণ স্বাধীনতা দিতেন; কখনও তাহাদিগকে তিরস্কার পর্য্যন্ত করিতেন না। বোধ হয় তিনি ভাবিতেন, ছেলেমেয়েদিগকে বাচনিক উপদেশ দেওয়া বা ভৎর্সনা করা অপেক্ষা নিজ জীবনের সদ্দৃষ্টান্তপ্রদর্শনই শ্রেয়ঃ।

দশ বৎসর বয়স পর্য্যন্ত প্রফুল্লচন্দ্র নিজ গ্রামের মাইনর স্কুলে শিক্ষালাভ করেন। তাহার পর হেয়ার স্কুলে ভর্ত্তি হন। চারি বৎসর পরে তিনি অ্যালবার্ট স্কুলে যান। সেখানে তিনি নিজ শ্রেণীর শ্রেষ্ঠ ছাত্র বলিয়া পরিচিত ছিলেন। তাঁহার পঠদ্দশার এই সময়টি স্মরণ করিলে এখনও তাঁহার হৃদয়ে আনন্দের উদ্রেক হয়। এখানেই তাঁহার শিক্ষক স্বর্গীয় কৃষ্ণবিহারী সেন মহাশয়ের সহিত তিনি বন্ধুত্বসূত্রে আবদ্ধ হন। শিক্ষক ও শিষ্যের সাহিত্যানুরাগ এই বন্ধুত্বের একটি প্রধান কারণ। প্রফুল্লচন্দ্রের পিতার একান্ত অভিলাষ ছিল যে, তাঁহার একটি সন্তান বিলাতে শিক্ষালাভ করে। কিন্তু জীবনের শেষভাগে নানাপ্রকার আর্থিক গোলযোগে পড়ায় তাঁহার এই ইচ্ছা পূর্ণ হইবার কোন সম্ভাবনা ছিল না। কিন্তু পিতার এই অভিলাষ প্রফুল্লচন্দ্রের হৃদয়ে নিরন্তর জাগরূক ছিল। এই জন্য তিনি অ্যালবার্ট স্কুলের তৃতীয় শ্রেণীতে থাকিতে থাকিতেই গোপনে কাহারও সাহায্য না লইয়া ফরাসী ও লাটিন ভাষা শিখিতে আরম্ভ করেন;—উদ্দেশ্য গিলক্রাইষ্ট বৃত্তি লইয়া বিলাতযাত্রা। তিনি এণ্ট্রান্স পাশ করিয়া মেট্রোপলিটান ইনষ্টিটিউশনে ভর্ত্তি হন; তথায় ৪র্থ বার্ষিক শ্রেণী পর্য্যন্ত অধ্যয়ন করেন। প্রফুল্লচন্দ্র মেট্রোপলিটানে অন্যান্য বিষয় এবং প্রেসিডেন্সী কলেজে বিজ্ঞান শিক্ষা করিতেন।

১৮৮২ খৃষ্টাব্দে গিলক্রাইষ্ট বৃত্তি লাভ করিয়া প্রফুল্লচন্দ্র বিলাত-যাত্রা করেন। তিনি গিলক্রাইষ্ট পরীক্ষা দেওয়ার কথা বরাবর পিতার নিকট গোপন করিয়া আসিয়াছিলেন; কারণ, কৃতকার্য্য হইলে পিতা বিস্মিত ও

আনন্দিত হইবেন। বিলাতযাত্রা সম্বন্ধে প্রফুল্লচন্দ্রের জননীদেবীর কোন কুসংস্কার বা আপত্তি ছিল না। তিনি আহ্লাদের সহিত পুত্রকে বিলাত যাইতে অনুমতি দেন। প্রফুল্লবাবু এডিনবরা বিশ্ববিদ্যালয়ে প্রবিষ্ট হন। রসায়ন তাঁহার বিশেষ অনুশীলনের বিষয় ছিল। অবশ্য পদার্থবিজ্ঞানও তিনি সম্যক্‌রূপে শিক্ষা করিয়াছিলেন। তিনি তথায় ছয় বৎসর কাল অধ্যয়ন করেন; এবং ১৮৮৭ খৃষ্টাব্দে ডি, এস, সি উপাধি লাভ করেন। উক্ত বিশ্ববিদ্যালয়ের উপাধি লাভার্থ তাঁহাকে যে রাসায়নিক প্রবন্ধ রচনা করিতে হইয়াছিল, তাহা এডিনবরা রয়্যাল সোসাইটীর কার্য্যবিবরণের মধ্যে প্রকাশিত হইয়াছিল। এডিনবরায় অবস্থিতি কালে তিনি "India before and after the mutiny"নামক একটি পুস্তক রচনা করেন। ইহার সম্বন্ধে প্রিন্সিপ্যাল স্যার উইলিয়ম মিওর বলেন "The Essay bore marks of rare ability." বিখ্যাত স্কটস্‌ম্যান পত্রিকা বলেন:—"It is a most interesting little volume, and we do not profess to wonder in the least that it has earned a considerable amount of popularity. It contains information in reference to India which will not be found elsewhere, and it is deserving of the utmost notice"—*The Scotsman*, Oct. 28, 1886.

মহাত্মা জন ব্রাইট্ বলেন:—"You write what is true on the Indian question and I trust your effort will yield some fruit."

বিলাতে প্রবাসকালে প্রফুল্লচন্দ্র অভিনিবেশপূর্ব্বক তদ্দেশবাসিগণের রাজনৈতিক জীবন পর্য্যবেক্ষণ করিতেন। রায়মহাশয় ১৮৮৯ খৃষ্টাব্দে প্রেসিডেন্সী কলেজের অন্যতর রসায়নাধ্যাপক নিযুক্ত হয়েন। তিনি ১৮৮৮ হইতে ১৮৯৭ পর্য্যন্ত ৯ বৎসরে নানা বৈজ্ঞানিক সভায় পঠন ও তাহাদের কার্য্যবিবরণের মধ্যে প্রকাশ করিবার জন্য ৯টি অভিনব গবেষণাপূর্ণ প্রবন্ধ প্রেরণ করেন। সমস্তগুলিই প্রকাশিত হইয়াছে। গত দুই বৎসরে তিনি পারদঘটিত তেরটি নূতন যৌগিক পদার্থ আবিষ্কার করিয়াছেন। তাঁহার অবিষ্ক্রিয়া সম্বন্ধে অধ্যাপক পেডলার বলেন:—"Dr. P. C. Ray by his discovery of the method of preparation of this compound (Mercurous Nitrite) has filled up a blank in our knowledge of the Mercury series."

অধ্যাপক এড্‌বার্ড ডাইবর্স অধ্যাপক রায়কে লিখিয়াছেন :—"Mr. Haga and myself prepared mercurous nitrite 11 years ago without knowing its composition ....a fact which does not lessen your own right to claim its discovery. You have discovered a very remarkable reaction in the oxidation in solution of potassium cyanide by mercuric nitrite becoming hyponitrite."

কলিকাতা-রিভিউ পত্রে একটি প্রবন্ধে নিম্নোদ্ধৃত কথাগুলি প্রকাশিত হয় :—

"Although Lefort, Gerhardt, Marignac and other chemists have been for a long time engaged in the study of the action of nitrite acid on mercury under varying circumstances yet they could not discover or prepare mercurous nitrite, the existence of which was indicated by the laws of chemical analogy. Mercury has been known to yield almost all the different classes of compounds known to chemists, such as sulphides, oxides, sulphates, nitrites etc, but the nitrite sereis of the element were found wanting. There is scarcely any information worth the name to be found about mercurous nitrite in Fremy's Encyclopedie Chimique. Even Roscoe and Schorlemmer, in their well-known treatise, do not so much as mention this compound, nor is there any reference to it to be found in the latest edition of Watt's *Dictionary of Chemistry*. It was reserved for Dr. P. C. Ray to discover this 'missing link' in the series of the compounds of Mercury, which had hither to baffled all the efforts of the European chemists either to discover or to prepare."

স্থানাভাবে আমরা Chemist and Druggist প্রভৃতি পত্রিকা এবং বার্টলো (Berthelot), বিক্টর মাইয়ার, রস্কো প্রভৃতি সুপ্রসিদ্ধ রাসায়নিকগণের মত উদ্ধৃত করিলাম না।

প্রেসিডেন্সী কলেজে রাসায়নিক গবেষণাগার স্থাপিত হওয়ায় অধ্যাপক রায়ের মত ব্যক্তির গবেষণা ও আবিষ্ক্রিয়ার সুবিধা হইয়াছে। এখানে শ্রীযুক্ত চন্দ্রভূষণ ও জ্যোতিভূষণ ভাদুড়ী ভ্রাতাদ্বয়ও রাসায়নিক গবেষণাকার্য্যে ব্যাপৃত আছেন। ইতিমধ্যেই তাঁহাদের পরিশ্রমের ফলও কিছু কিছু দৃষ্ট হইয়াছে। জ্যোতিভূষণ "On the transformation of the Hypochlorites into

Chlorates" নামক একটি প্রবন্ধ লিখিয়া মৌলিক গবেষণার জন্য প্রদত্ত ইলিয়ট পুরস্কার প্রাপ্ত হন। সম্প্রতি ইঁহারা দুই ভ্রাতায় মিলিয়া এসিয়াটিক সোসাইটীতে অধ্যবসায় ও কঠোর পরিশ্রমের ফলস্বরূপ একটি সন্দর্ভ প্রেরণ করিয়াছেন। বৈজ্ঞানিক যন্ত্রসংযোগে কোন তত্ত্বের প্রমাণ প্রদর্শনে চন্দ্রবাবুর মত নিপুণহস্ত লোক আমাদের দেশে অধিক দেখা যায় না। যন্ত্র রচনা ও নির্ম্মাণে তাঁহার হস্তের অসাধারণ কুশলতা দেখা গিয়াছে। সুযোগ অভাবে ইঁহার রাসায়নিক প্রতিভা সম্যক্ বিকাশপ্রাপ্ত হইতেছে না। প্রেসিডেন্সী কলেজের রাসায়নিক গবেষণাগার সংস্থাপনের জন্য অধ্যাপক পেড্‌লার আমাদের গভীর কৃতজ্ঞতার পাত্র। তাঁহারই যত্নে ইহা স্থাপিত হইয়াছে।

অধ্যাপক রায় ১৮৯২ খৃষ্টাব্দে পরলোকগত সতীশচন্দ্র সিংহ এম্, এর সহকারিতায় বেঙ্গল কেমিক্যাল এণ্ড ফার্ম্মাসিউটিক্যাল ওয়ার্কস্ নামক রাসায়নিক দ্রব্যের কারখানা স্থাপন করেন। ভারতবর্ষে রাসায়নিক এবং অপরাপর দ্রব্যজাত প্রস্তুত হয়, ইহা অধ্যাপক রায়ের একটি জীবনব্যাপী অভিলাষ। সেই মনোরথ কিয়ৎপরিমাণে পূর্ণ করিবার জন্য তিনি এই কারখানা স্থাপন করেন। এ বিষয়ে তাঁহার মূলমন্ত্র সুইফ্‌টের সেই পরিচিত কথা—

"Whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together."

মূলধন না থাকায় এবং সাধারণের সহযোগিতার অভাবে তাঁহাকে বহু অর্থসাপেক্ষ যন্ত্র ও প্রক্রিয়াদির পরিবর্ত্তে অনেক সহজ ও অল্পব্যয়সাধ্য প্রক্রিয়ার উদ্ভাবন করিতে হইয়াছে। এক্ষণে এই কারখানাটি দৃঢ়ভিত্তির উপর স্থাপিত হইয়াছে বলিতে পারা যায়। কিন্তু এজন্য প্রফুল্লবাবুকে অনেক আর্থিক ক্ষতি সহ্য করিতে হইয়াছে। প্রতি বৎসর বিদেশ হইতে ভারতবর্ষে অনেক কোটি টাকার ঔষধ, নৈল রং (Aniline dyes), দিয়াশেলাই, বাতী, সাবান এবং নানাবিধ রাসায়নিক দ্রব্য আমদানী হয়। এই সমস্তই ভারতবর্ষে প্রস্তুত হইতে পারে। এতদ্দ্বারা যে কেবল হাজার হাজার লোকের অন্নের সংস্থান হইতে পারে, তাহা নয়; কারখানার অধ্যক্ষগণও প্রভূত লাভবান হইতে পারেন। জার্ম্মানীকে অধুনা রাসায়নিক দ্রব্যের আকর বলিলেও চলে। ইহার বাণিজ্যিক উন্নতির প্রধান কারণ রাসায়নিক দ্রব্য প্রস্তুতকরণ বিষয়ে

জার্ম্ম্যান গবর্ণমেণ্টের উৎসাহলাভ। নানাবিধ নৈল রং এবং কয়লার আল্‌কাতরা হইতে উদ্ভূত ফেনাসিটিন, আণ্টিপাইরিন, সাল্‌ফোনেল প্রভৃতি সংশ্লেষিক (synthetical) ঔষধ প্রস্তুত করিয়া জার্ম্ম্যানেরা আজ ধনশালী জাতি হইয়া উঠিয়াছে। তাহাদের দেশের প্রত্যেক রাসায়নিক কারখানায় গবেষণা ও আবিষ্ক্রিয়া চলিতেছে। আর আমাদের দেশের ধনী লোকেরা এ বিষয়ে উদাসীন, গবর্ণমেণ্টও সহানুভূতিহীন। ইহার ফল যেরূপ শোচনীয় হইবার তাহাই হইয়াছে। কত বিশ্ববিদ্যালয়ের উপাধিধারী বৈজ্ঞানিক শিক্ষা পাইয়াও চাকরীর জন্য লালায়িত হইয়া বেড়াইতেছে। এ বিষয়ে আমাদের দেশের গবর্ণমেণ্ট যদি জাপানী গবর্ণমেণ্টের মত হইতেন, তাহা হইলে আমাদের দশা এমন হইত না। জাপানী গবর্ণমেণ্টের বৃত্তির সাহায্যে অনেক জাপানী যুবক ইউরোপ ও আমেরিকার পাশ্চাত্য বিজ্ঞান শিক্ষা করিয়া আসিয়া স্বদেশে বৈজ্ঞানিক গবেষণায় প্রবৃত্ত হইয়াছেন, এবং ইংরাজী ভাষায় একখানি বৈজ্ঞানিক কাগজ চালাইতেছেন। আমাদের বুদ্ধি আর কিছু জাপানীদের বুদ্ধি অপেক্ষা নিকৃষ্ট নয়। সুযোগের অভাবে আমরা জাতিসমাজে হীন হইয়া রহিয়াছি। গবর্ণমেণ্ট না করুন, দেশের ধনীদিগকে ত কেহ দিব্য দিয়া বলে নাই যে তোমরা বিজ্ঞানশিক্ষার্থ যুবকগণকে পাশ্চাত্য দেশে পাঠাইও না; কারখানা খুলিয়া আপনাদের স্বদেশের ধনবৃদ্ধি করিও না!

চারি বৎসর হইল অধ্যাপক রায় "সরল প্রাণিবিজ্ঞান" নামে একখানি সুন্দর প্রাণিবিদ্যা বিষয়ক সচিত্র পুস্তক লিখিয়াছেন। এই জন্য তাঁহাকে অনেক শ্রম ও অর্থব্যয় করিতে হইয়াছে। প্রাণিবিদ্যা বিষয়ে বঙ্গভাষায় ইহাই একমাত্র বৈজ্ঞানিক গ্রন্থ। অত্যন্ত দুঃখের বিষয় এই যে শিক্ষাবিভাগে বা সাধারণ পাঠকসমাজে এরূপ পুস্তকের সমুচিত আদর হয় নাই।

বিখ্যাত ফরাসী রাসায়নিক বার্টলো * ইহাকে একটি পত্রে যে যে পুরাতন

* M. Barthelot, Perpetual Secretary of the Academy of Sciences Paris। সংশ্লেষিক রসায়নে (synthetical chemistry) পৃথিবীতে ইহা অপেক্ষা পণ্ডিত কেহ জন্মগ্রহণ করেন নাই। ইনি Journal des Savants নামক পত্রে প্রকাশিত একটি প্রবন্ধে ডাক্তার রায়ের নাম উল্লেখ করিয়া ফরাসী ভাষায় যাহা লিখিয়াছেন তাহার ইংরাজী অনুবাদ প্রদত্ত হইতেছে;—"However it is necessary to examine certain documents indicated to me by a recent letter of Ray, Professor Presidency College Calcutta. According to the Savant (D' apres ce Savant), there exist treatises on alchemy in Sanskrit, * *. The subject is worthy of the most profound attention of those who are interested in the history of chemistry." ডাক্তার রায়কে Savant বলায় অত্যুক্তি হয় নাই।

সংস্কৃত গ্রন্থে রাসায়নিক দ্রব্যজাত প্রস্তুত করিবার প্রক্রিয়াদি আছে, তৎসম্বন্ধে নানা কথা জিজ্ঞাসা করিয়াছেন। তদুত্তরে প্রফুল্লবাবু একটি সারগর্ভ পুস্তিকা রচনা করিয়াছেন। ইহা এখনও মুদ্রিত হয় নাই; সম্ভবতঃ অচিরে পরিবর্দ্ধিত আকারে লণ্ডন ও পারিসে প্রকাশিত হইবে। এই পুস্তিকার নাম 'Materials for a neglected chapter in the History of Chemistry'। ইহার প্রথম খণ্ডে সংস্কৃত চিকিৎসাবিষয়ক গ্রন্থসকলের যে যে শ্লোকে রাসায়নিক দ্রব্য প্রস্তুত করিবার প্রক্রিয়াদি বর্ণিত আছে, তৎসমুদয়ের ইংরাজী অনুবাদ আছে। দ্বিতীয় খণ্ডে ভারতীয় রসায়নবিদ্যার উৎপত্তি ও ইতিহাস আলোচিত হইয়াছে। এই পুস্তিকা হইতে আমরা জানিতে পারিয়াছি যে, বাগ্‌ভট্ট-কৃত অষ্টাঙ্গহৃদয়, গোপালকৃষ্ণকৃত রসেন্দ্রসারসংগ্রহ, রামচন্দ্রকৃত রসেন্দ্র-চিন্তামণি, শার্ঙ্গধরসংহিতা, চক্রদত্তসংগ্রহ, রসরত্নসমুচ্চয় এবং ভাবমিশ্রকৃত ভাবপ্রকাশ এই কয়েকখানি গ্রন্থে নানাবিধ রাসায়নিক দ্রব্য প্রস্তুত করিবার প্রক্রিয়া বর্ণিত আছে। গ্রন্থগুলি একাদশ হইতে ষোড়শ খৃষ্টাব্দের মধ্যে ভিন্ন ভিন্ন সময়ে প্রণীত। এতন্মধ্যে রসরত্নসমুচ্চয় বিশেষ উল্লেখযোগ্য। কারণ ইহাতে নানাবিধ পারদঘটিত ঔষধ প্রস্তুতপ্রক্রিয়া ব্যতীত ঊর্দ্ধপাতন, তির্য্যকপাতনাদি প্রক্রিয়ার উপযোগী যন্ত্রের বর্ণনা আছে। অধ্যাপক রায়ের পুস্তিকায় উহাদের ছবি মুদ্রিত হইবে। বার্টলো মহোদয়ের ধারণা এই যে ভারতীয় রসায়ন পরোক্ষভাবে গ্রীকদিগের নিকট হইতে গৃহীত। প্রফুল্লবাবু নানা সুযুক্তি দ্বারা দেখাইয়াছেন যে ভারতবাসীগণ স্বাধীনভাবে রাসায়নিক জ্ঞান লাভ করিয়াছিলেন।

অধ্যাপক রায়ের দেহ সুস্থ ও সবল নহে। প্রায় কুড়ি বৎসর হইল, তিনি অজীর্ণ রোগে ভুগিতেছেন। তাহার উপর প্রায় ছয় বৎসর পূর্ব্বে অনিদ্রা রোগে কষ্ট পান। এখনও এই রোগ হইতে নিষ্কৃতি পান নাই। এই সকল কারণে প্রফুল্লবাবুকে রাত্রে, এমন কি সন্ধ্যাকালেও কঠোর জ্ঞানানু-শীলন ত্যাগ করিতে হইয়াছে। সময় সম্বন্ধে এইরূপ বাঁধাবাঁধির মধ্যে থাকিয়াও যে তিনি এত কঠিন শ্রমসাপেক্ষ আবিষ্ক্রিয়া করিতে সক্ষম হইয়া-ছিলেন, তাহা কেবল কার্য্যের শৃঙ্খলা এবং কঠোর নিয়মাধীনতার গুণে। প্রাতঃকালের ২ঘণ্টা (গ্রীষ্মকালে ৬॥০টা হইতে ৮॥০টা এবং শীতকালে ৭টা হইতে ৯টা) তিনি নিয়মিত বিদ্যাচর্চ্চায় যাপন করেন। অধ্যাপনার জন্য ১ কি ২ ঘণ্টা বাদ দিয়া ১১টা হইতে ৪টা পর্য্যন্ত তিনি কলেজে বৈজ্ঞানিক

অভিনব গবেষণায় যাপন করেন। এক্ষণে নানাবিধ গবেষণায় তাঁহার হস্ত পূর্ণ। গত বৎসর হইতে তিনি অপরাহ্নে মুক্ত বাতাসে অনেকক্ষণ ভ্রমণের পর সন্ধ্যার সময় এক বা দেড় ঘণ্টা লঘু সাহিত্য পাঠ করিতে আরম্ভ করিয়াছেন। ইহাই তাঁহার কাজের নিয়ম। সমস্ত বৎসর কলেজের ছুটির সময়ও তিনি ঠিক এই নিয়মানুসারে কাজ করেন। ছুটির সময়েই তিনি প্রাণের আকাঙ্ক্ষা মিটাইয়া স্বাধীন গবেষণা কার্য্যে সময় ক্ষেপণ করেন। তিনি আমাকে বলিয়াছেন, জন মর্লী অধ্যয়ন সম্বন্ধে একটি বক্তৃতাতে যে পরামর্শ দিয়াছেন, তিনি তাহারই অন্তর্নিহিত সঙ্কেতানুসারে কাজ করিতে চেষ্টা করেন।

"Now in half an hour I fancy you can read fifteen or twenty pages of Burke; or you can read one of Wordsworth's masterpieces—say the lines on Tintern; or say, one third * * of a book of the Iliad or the Æneid * *. But try for yourselves what you can read in half an hour. Then multiply the half hour by 365, and consider what treasures you might have laid by at the end of the year, and what happiness, fortitude, and wisdom they would have given you for a life time." *

একটি কথা আছে—"ছাত্রাণামধ্যয়নম্ তপঃ।" প্রফুল্লচন্দ্র অধ্যাপক, কিন্তু আমাদের দেশের অধিকাংশ উপাধিধারীর মত তাঁহার শিক্ষাকাল উত্তীর্ণ হইয়া যায় নাই। এখনও জ্ঞানান্বেষণই তাঁহার প্রধান কার্য্য। কিছু দিন পূর্ব্বে একখানি পত্রে কথাপ্রসঙ্গে তিনি আমায় লিখিয়াছিলেন— I was never a more *bonafide* student than to-day. বাস্তবিক পুরাকালে শিক্ষার্থীদের যেরূপ ব্রহ্মচর্য্যের ব্যবস্থা ছিল, প্রফুল্লচন্দ্রের জীবন তাহার একটি দৃষ্টান্তস্থল। ইনি এখনও অবিবাহিত আছেন। ইঁহার বাসভবনে, আহারে, পরিচ্ছদে বিলাসিতার লেষমাত্র নাই। ইনি চাল-চলন ও কথাবার্ত্তায় এরূপ সাদাসিদে ও আড়ম্বরহীন যে, "বিলাত ফেরৎ" বলিয়া কেহই ইঁহাকে সন্দেহও করিতে পারে না। এ সকল বিষয়ে তিনি বেহদ্দ বাঙ্গালী; কিন্তু ধর্ম্মভাবে, চরিত্রের পবিত্রতায় ও জ্ঞানস্পৃহায় বিদ্যার্থীমাত্রেরই এবং অপরের অনুকরণযোগ্য। দেশহিতকর নানাবিধ

* University Extension Addresses, pp. 69-70.

কার্য্যে ইঁহার যোগ আছে। গরিব দুঃখীর সেবায় ইনি মুক্তহস্ত। দানশীলতা ইঁহার চরিত্রের অন্যতম ভূষণ। বিখ্যাত স্যার আইজ্যাক নিউটন বলিতেন—"those who gave nothing before death never, in fact, gave at all", অর্থাৎ যাঁহারা জীবদ্দশায় কিছুই দান করেন না তাঁহাদের দান দানই নহে। প্রফুল্লচন্দ্র এই মহাজন বাক্য সদা স্মৃতিপথে জাগরূক রাখিতে চেষ্টা করেন। ভাল সাজিবে বলিয়াই বিধাতা বুঝি ইঁহার মত জ্ঞানলিপ্সুদিগকে বিনয়ভূষণে অলঙ্কৃত করেন। ইঁহার সরলতা বালকোপম।

পঠদ্দশায় প্রফুল্লচন্দ্র ইংরাজীসাহিত্য, ইতিহাস ও জীবনচরিত পাঠে একান্ত অনুরক্ত ছিলেন। এখনও তিনি গোল্ডস্মিথ, আর্বিং, থ্যাকারে, ডিকেন্স ও জর্জ্জ ইলিয়টের গ্রন্থাবলী পড়িতে ভালবাসেন। জীবিত ঔপন্যাসিকগণের মধ্যে তিনি কেবল এড্‌নালায়েলের গ্রন্থাবলীর পক্ষপাতী, বিশেষতঃ তাঁহার "We Two" এবং "Donovan"-এর। বাইবেলের নূতন অংশ, এমার্সন, টেনিসন (কেবল In Memoriam, Enoch Arden এবং Guinevere), মার্টিনো (Endeavours after the Christian Life এবং Hours of Thought), এপিকটেটস এবং মার্কস অরীলিয়স্‌ তাঁহার অনুরাগভাজন। তাঁহার জীবনে শেষোক্ত দুই জনের প্রভাব বিশেষভাবে লক্ষিত হয়। ঐশ্বর্য্য যে ধনের প্রাচুর্য্যে হয় না, কিন্তু অভাবের অল্পতাতেই হয়, ইহা তিনি বিশেষভাবে অনুভব ও উপলব্ধি করিয়াছেন। তাঁহার অন্তরঙ্গ বন্ধুর সংখ্যা যেমন কম, প্রিয় গ্রন্থকারের সংখ্যাও তদ্রূপ। কিন্তু তিনি তাঁহার প্রিয় কতকগুলি পুস্তক পুনঃ পুনঃ পাঠ করেন। তিনি আমাকে বলিয়াছেন, কখন কখন উপন্যাসবর্ণিত অনেক নরনারীর সহিত তিনি দিবস রজনী ঘনিষ্ঠভাবে যাপন করেন। তত্ত্ববোধিনী, বিবিধার্থসংগ্রহ, রহস্যসন্দর্ভ, বঙ্গদর্শন, আর্য্যদর্শন, বান্ধব প্রভৃতি মাসিকপত্রের অধিকাংশ প্রবন্ধ তিনি পাঠ করিয়াছেন। মধুসূদন, দীনবন্ধু প্রভৃতি গ্রন্থকারের লেখাও তিনি পাঠ করিয়াছেন। বাঙ্গালা সাহিত্যের সহিত তাঁহার যে পরিচয় নাই, তাহা নয়; কিন্তু উহাতে তাঁহার বিশিষ্ট অনুরাগ নাই। তিনি বলেন যে, পাশ্চাত্য গ্রন্থকারেরাই জ্ঞানপিপাসা নিবারণ করিতে পারেন। সে যাহা হউক, বঙ্কিমবাবুর বিষবৃক্ষ ও কৃষ্ণকান্তের উইল তিনি খুব ভালবাসেন। কিন্তু তিনি বলেন; "স্কট Count Robert of Paris ও Castle Dangerous লেখায় যেমন তাঁহার যশের লাঘবই হইয়াছিল,

আনন্দমঠ, সীতারাম ও রাজসিংহ লেখায় বঙ্কিমবাবুরও তেমনি অগৌরব হইয়াছে।”

অধ্যাপক রায় ফরাসী, জার্ম্মান ও লাটিন ভাষা জানেন। জার্ম্মান ও ফরাসী ভাষা না জানিলে রসায়ন বিজ্ঞানে বিশিষ্ট জ্ঞান লাভ করা যায় না। বিখ্যাত রাসায়নিক বুর্টস্ (Wurtz) বলেন—La Chimie est Une Science francaise—রসায়ন ফরাসী বিজ্ঞান। প্রফুল্লবাবু বলেন—তাঁহার রাসায়নিক জ্ঞানের চৌদ্দআনা ফরাসী ও জার্ম্মান গ্রন্থ হইতে লব্ধ।

শ্রীরামানন্দ চট্টোপাধ্যায়

আচার্য্য প্রফুল্লচন্দ্র

গত শতাব্দীর প্রথমভাগে যখন গভর্ণমেণ্টের ব্যয়ে বাঙলাদেশে স্কুল কলেজ প্রতিষ্ঠা করবার প্রস্তাব প্রথম উত্থাপিত হয়, তখন কোন্ ভাষায় আর কি বিষয়ে শিক্ষা দেওয়া হবে, তা নিয়ে মহা তর্ক উপস্থিত হয়।

এক দল প্রস্তাব করেন যে, এই সরকারী শিক্ষার ভাষা হবে সংস্কৃত, আর বিষয় হবে সংস্কৃতশাস্ত্র।

আর দ্বিতীয় দলের মত, ইংরাজী ভাষায় ইউরোপীয় জ্ঞানবিজ্ঞানের শিক্ষা দেওয়াই গভর্ণমেণ্টের কর্ত্তব্য।

প্রথম দলকে সেকালে Orientalist বল্‌ত, আর দ্বিতীয় দলকে Anglicist। রাজা রামমোহন রায় ছিলেন এই দ্বিতীয় দলের মুখপাত্র। প্রধানতঃ তাঁর চেষ্টা ও তাঁর যত্নে Hindu College প্রতিষ্ঠিত হয়, যে Hindu Collegeএর পরিবর্ত্তিত ও পরিবর্দ্ধিত সংস্করণ হচ্ছে বর্ত্তমান কলিকাতা বিশ্ববিদ্যালয়।

এই উপলক্ষ্যে রামমোহন রায় Lord Amherstকে যে পত্র লেখেন, তার এক অংশ নিম্নে উদ্ধৃত করে দিচ্ছি।

"When this seminary of education was proposed, we understood the Government of England had ordered a considerable sum of money to be annually devoted to the instructions of its Indian subjects. We were filled with sanguine hopes that this sum would be laid out in employing Europeans of talent and education to instruct the natives of India in Mathematics, Natural Philosophy, Chemistry, Anatomy and other useful sciences, which the natives of Europe have carried to a degree of perfection that has raised them above the inhabitants of other parts of the world."

আজ থেকে প্রায় একশ কুড়ি বৎসর পূর্ব্বে, যে সময়ে ইউরোপের লোকেও বিজ্ঞানের এই অত্যাশ্চর্য্য ভবিষ্যৎ কল্পনা করতে পারে নি, সেই সময়ে

একটি বাঙালী মহাপুরুষের জ্ঞানদৃষ্টিতে বিজ্ঞানের অপূর্ব্ব মাহাত্ম্য ধরা পড়ে; এবং তিনি ইউরোপের নব বিদ্যা যাতে দেশের লোক আয়ত্ত করতে পারে তার জন্য লালায়িত হয়েছিলেন। বিজ্ঞানের চর্চ্চাই যে ইউরোপের অধিবাসীদের পৃথিবীর আর সকল জাতির অপেক্ষা উন্নত ও শক্তিশালী করেছে, এ সত্য তাঁর চোখ এড়িয়ে যায় নি। ভারতবাসীদের কি উপায়ে শক্তিশালী ও উন্নত করা যায় এই ভাবনাই ছিল রামমোহন রায়ের সকল জ্ঞান ও কর্ম্মের প্রেরণা।

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রামমোহন রায়ের অক্লান্ত চেষ্টার ফলে হিন্দু কলেজ প্রতিষ্ঠিত লহ। কিন্তু এ কলেজে useful science শিক্ষা দেবার কোনও ব্যবস্থা ছিল কি না, আমি জানিনে। খুব সম্ভবতঃ ছিল না। কারণ ছেলেবেলায় উক্ত কলেজে শিক্ষিত যে সব লোকের সাক্ষাৎ লাভ করেছি, তাঁদের যে Newtonএর অপেক্ষা Shakespeareএর সঙ্গে ঘনিষ্ট পরিচয় ছিল, সে বিষয়ে সন্দেহ নেই। তাঁরা ইংরাজী শিখেছিলেন, কিন্তু উক্ত ভাষার মারফৎ বিজ্ঞান শেখেন নি।

আমরা বাঙালীরা কতদিন হতে বিজ্ঞান শিক্ষা লাভ করছি, তা আমি জানিনে। তবে আমার জ্ঞান হয়ে অবধি দেখছি আমাদের বিশ্ববিদ্যালয়ের শিক্ষা দু-ভাগে বিভক্ত। Science course ও Arts courseএর বিভাগ অনেককাল হতে প্রচলিত আছে। Mathematics, Physics এবং Chemistry শিক্ষার ব্যবস্থা কলিকাতা বিশ্ববিদ্যালয় বহুকাল পূর্ব্বে করেছেন। কিন্তু তার ফলে বহুকাল যাবৎ এদেশে কোনও বৈজ্ঞানিক জন্মগ্রহণ করেন নি। এর কারণ বোধ হয়, যে হিসেবে আমরা শাস্ত্রচর্চ্চা করে থাকি, সেই হিসেবেই আমরা পূর্ব্বে বিজ্ঞানচর্চ্চা করতুম। অর্থাৎ ইউরোপীয় বৈজ্ঞানিকরা জড়জগৎ সম্বন্ধে যে সকল সত্য আবিষ্কার করেছিলেন, সেই সকল সত্যকে চূড়ান্ত হিসাবে আমরা গ্রাহ্য করে এসেছি। জড়জগতের সকল রহস্য যে উদ্ঘাটিত হয় নি, এবং আমরাও যে বৈজ্ঞানিক পদ্ধতিতে Physics ও Chemistryর বহু অনাবিষ্কৃত সত্য উদ্ধার করতে পারি, সম্ভবতঃ এ ভরসা আমাদের ছিল না।

রামমোহন রায় পূর্ব্বোক্ত পত্রে সংস্কৃতশাস্ত্র চর্চ্চা সম্বন্ধে নানারূপ বিদ্রূপ করেছেন। কারণ পূর্ব্বে কে কি বলে গিয়েছেন কেবলমাত্র সেই সব কথায় জ্ঞানলাভ করলেই এ বিশ্ব ও মানবজীবন সম্বন্ধে জ্ঞানের কোনরূপ বৃদ্ধি কি

উন্নতি হয় না। রামমোহন রায় চেয়েছিলেন সেই সেই শিক্ষা যার ফলে স্বজাতির আত্মশক্তি প্রবুদ্ধ ও প্রস্ফুটিত হবে এবং যার প্রসাদে বাঙালীজাতি ইউরোপের অধিবাসীদের তুল্য জ্ঞানে ও কর্ম্মে উন্নত হবে।

বৈজ্ঞানিক জ্ঞানের বিশেষত্ব এই যে, মানুষে নিজের চেষ্টায় এ জ্ঞানের মাত্রা বাড়িয়ে দিতে পারে এবং এ জ্ঞানকে কর্ম্মে ভাঙিয়ে নিতে পারে যার ফলে সমগ্র সমাজ শক্তিশালী হয়ে উঠতে পারে।

(৩)

আমি যখন স্কুলের চৌকাঠ ডিঙিয়ে কলেজে প্রবেশ করি, তার অব্যবহিত পরেই এই সুসংবাদ শুনি যে রাজা রামমোহন রায়ের মনস্কামনা পূর্ণ হয়েছে। দু'জন বাঙালী অধ্যাপক বিজ্ঞানের নূতন তত্ত্ব আবিষ্কার করেছেন,—একজন Physicsএর আর একজন Chemistryর। একজনের নাম শ্রীজগদীশচন্দ্র বসু আর একজনের নাম শ্রীপ্রফুল্লচন্দ্র রায়। যদিচ আমি বিজ্ঞানের কোনরূপ ধার ধারতুম্ না, তথাপি এ সংবাদ শুনে আমি মহা উৎফুল্ল হয়ে উঠি। কারণ সেদিন মনে হয় যে, বাঙালীজাতির মনের ইতিহাসের একটি নূতন অধ্যায়ের সূত্রপাত হল; এবং বর্ত্তমানে বাঙালীজাতি সাহিত্যজগতে যে কৃতিত্বের পরিচয় দিয়েছে, ভবিষ্যতে তারা বিজ্ঞানের ক্ষেত্রেও সমান কৃতিত্বের পরিচয় দেবে এবং আমাদের বিজ্ঞানচর্চ্চা কেবলমাত্র মুখস্থ বিদ্যায় পরিণত হবে না। এ সুফল যে ফলেছে, সে বিষয়ে আজকের দিনে আর সন্দেহের অবসর নেই।

এ বিদ্যার প্রধান গুণ এই যে, বিজ্ঞান প্রয়োগপ্রধান শাস্ত্র। বিশ্বের এ জ্ঞানকে যদি মানুষ কর্ম্মে ভাঙিয়ে নিতে না পারত, তবে আজকের দিনে মানবসমাজে বিজ্ঞানের এ অসাধারণ প্রতিপত্তি কখনোই ঘটত না।

আচার্য্য প্রফুল্লচন্দ্র রায় তাঁর Chemistryর জ্ঞানকে সমাজের কাযে লাগাতে তাঁর শিষ্যদের শিখিয়েছেন। Science যে মানুষের পক্ষে useful, শুধু ধ্যান ধারণার বস্তু নয়—এ সত্য তিনি হাতেকলমে প্রমাণ করেছেন। বিজ্ঞানের ক্ষেত্রে তিনি বহু নূতন জ্ঞানী ও নূতন কর্ম্মীর সৃষ্টি করেছেন। কারণ এই উভয় দলের অন্তরে যে তিনি নূতন প্রাণের সঞ্চার করেছেন সে বিষয়ে কোন সন্দেহ নেই। এই কারণে বাঙালীজাতির কাছে আচার্য্য প্রফুল্লচন্দ্র একটি অপূর্ব্ব মহাপুরুষ হিসেবে যে চিরস্মরণীয় হয়ে থাক্‌বেন, এ বিষয়েও কোন সন্দেহ নেই।

শ্রীপ্রমথ চৌধুরী

A New Proof of Fermat's Theorem

By Sarasi Lal Sarkar (Calcutta).

I have carried on some investigations into the properties of numbers by starting from the properties of recurring decimals, which have been investigated by me, to find out some general truths. I have been able to prove that in the case of the fraction $1/p$, where p is a prime number, if the fraction be reduced to any scale of notation S, where S represents any integral number, the recurring period, firstly, will be a pure recurring decimal and not a mixed recurring decimal, and secondly, if this recurring period consists of k number of digits, k will be a factor of $(p-1)$.

I have to omit here the proofs of all these, which are rather long. It can be shown that some of the well-known theorems in the theory of numbers, e.g. Fermat's theorem, Extension of Fermat's theorem, Wilson theorem, can be proved with the help of the above theorem.

As an example it is being shown here how Fermat's theorem can be easily proved with the help of the above theorem.

If $1/p$ be converted into recurring decimal in the scale of notation S, we may suppose that the recurring period is of the form

$$\dot{a}_1 a_2 a_3 \ldots\ldots\ldots\ldots\ldots\ldots \dot{a}_k$$

i.e., consisting of k number of terms.

It has been proved before that k must be a multiple of $(p-1)$.

Suppose $(p-1)$, when divided by k, is n.

Let the recurring period of decimal be taken for n times, then the number of digits in the recurring period will be $(p-1)$.

Let this be converted into a vulgar fraction following the usual method,

Then the fraction will be of the form

$$\frac{\cdot a_1\ a_2\ a_3 \ldots\ldots\ldots a_k a_1\ a_2 \ldots\ldots\ldots a_k \ldots\ldots\ldots a_k}{(S-1)\ (S-1)\ (S-1) \ldots\ldots\ldots \text{to } (p-1) \text{ terms}}$$

Where a_1, a_2, a_3, etc.........a_k and $(S-1)$ represent different digits of the numerator and denominator respectively of a vulgar fraction.

The recurring period has been taken in the numerator n times, so that there will be $(p-1)$ number of digits both in the numerator and the denominator.

Since this vulgar fraction on being simplified will be reduced to $\frac{1}{p}$

$\therefore$ the denominator of the fraction will be divisible by p.

$\therefore$ the number represented by the digits

$(S-1)(S-1)$....................to $(p-1)$ terms

must be divisible by p.

Since the number

$(S-1)(S-1)$......................to $(p-1)$ terms

$=(S-1)\times\{111$....................to $(p-1)$ terms$\}$

$\therefore$ either $(S-1)$ will be divisible by p

or the number 111....................to $(p-1)$ terms will be divisible by p.

If $(S-1)$ is divisible by p, then since $S^{p-1}-1$ is divisible by $S-1$.

$\therefore S^{p-1}-1$ is divisible by p.

Secondly, let us suppose that the number

1111...........to $(p-1)$ terms is divisible by p.

1111...........to $(p-1)$ terms

$$=S^{p-2}+S^{p-3}+S^{p-4}+\ldots\ldots\ldots+1$$

$$=\frac{S^{p-1}-1}{S-1}$$

This must be divisible by p.

$S^{p-1}-1$ must be divisible by p.

$S^{p-1}-1$, is divisible by p, provided p is a prime number. This theorem is known as the Fermat's theorem.

It is a matter of intense pleasure to all Indians that their revered Acharyya Sir Prafulla Chandra Ray has, by the grace of God, been gifted with long life and has just completed his seventieth year. Ever since (thirty years ago) I have had the good fortune of being his pupil, I have felt the greatest admiration and reverence for Acharyya Ray. He has always been an embodiment of simplicity and a friend of the poor students. When I was at college we used to feel the greatest affection for him, not only because of his sound learning, original research work, his lucid and humorous way of teaching, and his love for work and students but also for his tattered clothes and charity to the poor. He felt so strongly for those who were not blest with riches that whenever he got his salary, he kept only Rs. 100 per month for his bare maintenance and distributed the rest among those who were in need.

Such an ideal soul could not rest content with Professorial work, how noble soever it may be. He burnt with zeal to find out how he could relieve the distress of the masses. And when Mahatma Gandhi came forward with his programme of Khadi, it could not take Acharyya Ray long, with his clear vision and sympathetic heart, to find out that in cottage and small industries—of which Khadi is a symbol and an important example—lay the salvation of the masses and the unemployed middle classes. He threw himself with all his weight—for in his frail body lies a mighty soul—into the Khadi movement, and laid the foundation in Bengal, well and truly, of the desire and action of the uplift of the massess.

There is hardly any occasion of distress—be it famine or flood

or earthquake—when Acharyya Ray does not sacrifice himself to administer relief.

He is the beacon light to whom the young, the enthusiastic, the patriotic look to keep themselves along the correct path. He is the servant of the poor. He is the prophet of the down-trodden. Through him God manifests Himself in a hundred ways. Glory unto God who in His infinite mercy has created such a noble soul to be the ideal of mankind!

D. P. Khaitan.

The Singbhum China Clay Industry

By L. Gupta (Singbhum).

(Plate XVII).

In India the importance of a thriving China Clay Industry is not generally understood by people engaged in different trades or the laymen. It requires pointing out that on the successful development of this industry depends the manufacture of high class potteries and porcelain, paper and cotton textile goods. Not many years ago the entire need of this country in these regards was met by the imported commodity. It is only for the last 10-15 years that Indian China clay has come to play its role. The magnitude of this industry can be gauged by the fact that England and Northern Ireland manufacture on an average 8,00,000 tons of China clay annually valued £18,00,000 and the major portion of this immense production is carried out in Cornwall and shipped out to distant ports of the world. To-day about 22,000 tons of English China clay enter into India, mainly through the port of Bombay.

An attempt is made in this article to give a general outline of the China clay industry in Singbhum, which, in the opinon of the writer, can be developed to a flourishing condition better than any other known area in India, and incidentally to draw the attention of all the consumers of clay that it will benefit them and the country as a whole to take to Indian clay. A paper published by Mr. Kerridge in T. M. G. Ins. of India, vol. XXIV, part 3, 1930 should be read by those who are interested in the subject.

The Geological Department of the Government of India so far, it appears, have neither carried out any systematic prospecting work regarding the existence of China clay deposits in the country

nor have they made a possible estimate of the total quantity available from the existing well-known fields. China clay is known to occur in several parts of India and some of the deposits in Delhi, Bhagalpore, Jubbulpore and Singbhum are actually being worked on a commercial scale for the last few years. At present bulk of the productions comes from Delhi and Singbhum. Yields from Bhagalpore and Jubbulpore areas have declined. The quality of the clay produced in these areas differs and the Singbhum clay is found to be the best as regards whiteness, plasticity and suspensibility. From the amount of prospecting work conducted by the Kasimbazar China clay Mines and other parts in Singbhum it is conclusively proved that the area holds clay in abundance. It is in a position to supply much of the requirements of India for a considerable length of time. Developments can only be expected if scientific mining and refining operations are adopted.

The following import figures and the Indian productions will be found useful.

IMPORT FIGURES

Quantity

	Tons 1924-25	Tons 1925-26	Tons 1926-27	Tons 1927-28	Tons 1928-29	Tons 1929-1930
Bengal	3,263	4,951	4,398	3,546	3,374	2,864
Bombay	18,810	16,650	21,957	22,984	11,466	21,840
Sind	...	4	...	...	...	...
Madras	397	461	374	147	97	224
Burma	2	10	22	9	...	22
Total	22,472	22,076	26,731	26,688	14,937	24,950

Value of Imports

	1924-25 Rupees	1925-26 Rupees	1926-27 Rupees	1927-28 Rupees	1928-29 Rupees	1929-30 Rupees
Bengal	2,54,238	2,93,672	2,91,891	2,39,442	2,19,493	1,94,913
Bombay	16,01,124	13,04,429	16,77,213	15,97,362	7,36,730	12,93,894
Sind	...	375	...	59	...	...
Madras	38,233	41,022	32,359	13,331	11,203	22,156
Burma	127	693	180	784	...	4,368
Total	18,93,772	16,40,171	20,01,643	18,50,978	9,67,426	15,15,346
Average value per ton	Rs. 84/-	Rs. 74/-	Rs. 75/-	Rs. 68/-	Rs. 64/-	Rs. 60/-

The average import per year is 22,309 tons.

INDIAN PRODUCTIONS

Quantity

	1926 Tons	1927 Tons	1928 Tons	1929 Tons	1930 Tons
Bhagalpur	3,870	4,490	7,186	4,082	434
Singbhum	3,351	5,948		5,336	9,212
Jubbulpore	4,914	8,906	...	...	...
Delhi	3,791	4,300	...	2,310	3,864
Ajmir-Merwara	...	...	...	...	2
Total :—	15,926	23,644	7,186	11,728	13,512

The average production per year is 14,399 tons.

The History of the Singbhum Clay Mines—Singbhum was originally in the Province of Bengal but with the introduction of the Reform Scheme it was transferred from that province and given over to Bihar and Orissa. It is a Government Khas Mahal and is under the management of the so-called Kolhan Estate. All mines within this district are therefore lease-hold properties. The clay mines were opened after the Great War, and like the coal mines in India the pioneering work goes to the credit of Bengali enterprise. At present of the three mines in operation two are in the hands of Bengali proprietors and the third belongs to a Marwari gentleman. Several attempts have been made now and then to open up more quarries but these have resulted in failure due chiefly to lack of proper working and to the poor quality of refined clay produced, which could not secure any market. The mines are in the infant stage and cannot be compared with the highly developed conditions under which English and American clay mines are worked. People of this country imagine that the production of good China clay is quite an easy job. That it is not so is apparent only to those, who have just visited the mines in the foreign countries and studied the article carefully.

The Kasimbazar Mines have made some attempt to work the mines on modern principle but it is to be acknowledged that their expectations have not been fulfilled. In the beginning these mines were managed by several Europeans, who came one after

another to try new schemes. No expert, who had previously been in this indstry in his own country, was engaged and so trial experiments were conducted which did not stand the test of time. It is difficult to understand why the person originally responsible for these mines did not think out a proper lay-out of the refining system and the equipments conducive to successful production. The result was that the late lamented Maharaja Manindra Chandra Nandy, who followed the advice of his so-called experts and put in quite a good amount of capital in this industry, did not live to see the concern on a profit-earning basis. He had continually lost for 6 years, while others in the business were making decent profits. The writer took up the management of the Kasimbazar Mines early in 1930. It is to the good fortune of the present Maharaja of Kasimbazar, Srish Chandra Nandy, that the mines are now working on a profit. The concern requires more capital for the purpose of setting up modern machineries so as to be equipped for greater and better production. There is much to be done yet in the matter of refining, as the qualities of clay demanded by potteries, paper and cotton mills are all different and arrangements for producing different grades of refined clay are lacking. A move in the right direction is expected from the owner.

The Nature and the Working of the Mines—Unlike the system of working adopted in Delhi and Bhagalpore (Pathuriaghatta) where the mining is conducted on the tunnel system or the working of the water pressure washing system as is done in Cornwall, the Singbhum mines are worked on the principle of open quarrying by hand labour. It is observed that all the best deposits are either under the good cultivation lands or near river beds. They really run within valleys. The nature of deposits varies. They exist in pockets as well as in long running beds, some of which are of large dimensions. Clay sticks between 6′-8′ from the overlaying ground and at times at a still lower depth. The quarries are worked in stages or stairways to prevent sidefall. The Kasimbazar Mines have worked some of their deposits to a depth of 60′-70′ and in length and breadth 600 by 400 feet. Greater

depths have not been reached due to heavy percolation of water which makes it impossible for hand labour to work in the absence of a better arrangement for coping with heavy water percolation. The only equipment at present in use is the pumping by centrifugal pumps by low power oil engines. It will certainly pay to put in high power pumps and work up to greater depths, as better quality of clay is expected in lower strata.

The nature of soils under which good deposits are observed will make an interesting study for a geologist. Miners and supervisors who are at work for some years can guess by experience and point out places where good beds of clay are expected. It is a curious fact that these surmises are found correct in most cases.

It is said that the origin of clay is felspathic and other aluminous minerals which have undergone chemical reactions from within, or it has been formed by the mechanical disintegration of rocks of argillacious character. Time has played a great role in this formation and water and carbonic acid have wrought the change. Decomposition has set in, salts of soluble character are washed away, while an insoluble silicate of alumina is left behind in a hydrated condition in a state of mechanical association with free silica and other substances. The earth is in a biotic state and this process is carried on from age to age.

When the quarries are opened up, one beholds a most wonderful work of Nature. Here beneath a bed of red morrum and ordinary soil you notice a layer of pure white clay. There under a layer of pure white sand you have beds of good China clay and further on, perhaps below stretches of hydrated brick-red iron and manganese stained soil, you come across the purest variety of kaolin of dazzling whiteness.

Very little of undecomposed felspar and mica are noticed in Singbhum kaolin showing that the decomposition in these areas has been fairly complete. Copper-bearing rocks are of common occurrence in Singbhum clay quarries.

Only manual labour is engaged in the mining operations and the implements required are ordinary kodalies, picks and cane buskets. The working season in the year is about 10 months

from the middle of September to the end of June or until monsoon breaks in. Both male and female coolies are empolyed and at the Kasimbazar Mines local and imported labour from other districts are recruited. During normal working period a strength

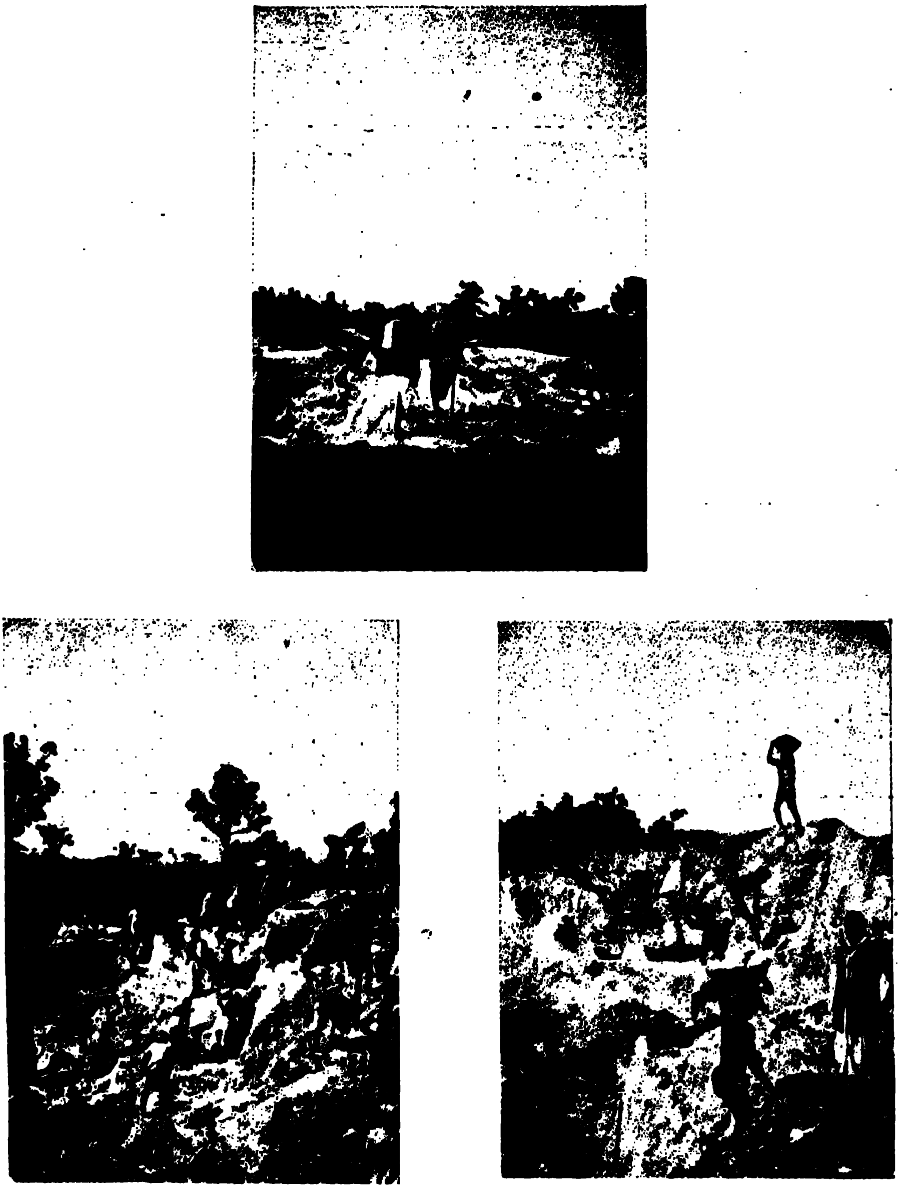


Fig. 1.—*Side view of the Quarry.*—Picture on the top show a quarry just being opened up, while those at the bottom apparently point out an advanced working stage.

of about 600 coolies is maintained. The earth cutting and removal of clay are done mostly by contract system and the rates in force differ according to the depth worked at and the distance of over-burden to be dumped out. The clay is carried outside the quarry and stacked in heaps where sorting and picking follow. Finally the clay is removed in tubs running on tracks and driven by hand or hauled up by a steam haulage engine in batches inside the refining plants and unloaded in sheds or sidings according to the convenience of subsequent treatment.

The usual earning of a male cooly is about Rs. 2-8 and that of a female is Re. 1-12 per week. The average cost per ton of crude clay delivered inside the factory with overhead charges is about Rs. 5 per ton.

Nature and proximate analysis of Crude Clay—The nature and proximate analysis of crude clay varies from place to place. The most important consideration from the point of view of refining is the whiteness of crude clay and the presence of gritty matters or free sand. The shade of the clay ranges from a brilliant white to a creamy colour. Some clay is also tinged faint greenish and yellowish. This tinged clay is the most difficult to deal with. It is presumably due to organic colouring matters and minute traces of copper and iron, which persist throughout the refining operation. This colour is somewhat discharged when exposed to the sun due apparently to the partial decomposition of the organic matter and the anhydrous state of the iron and copper salts. The colour of this sort of clay reappears to some extent when the refined clay is wetted.

Proximate analysis of Crude Clay

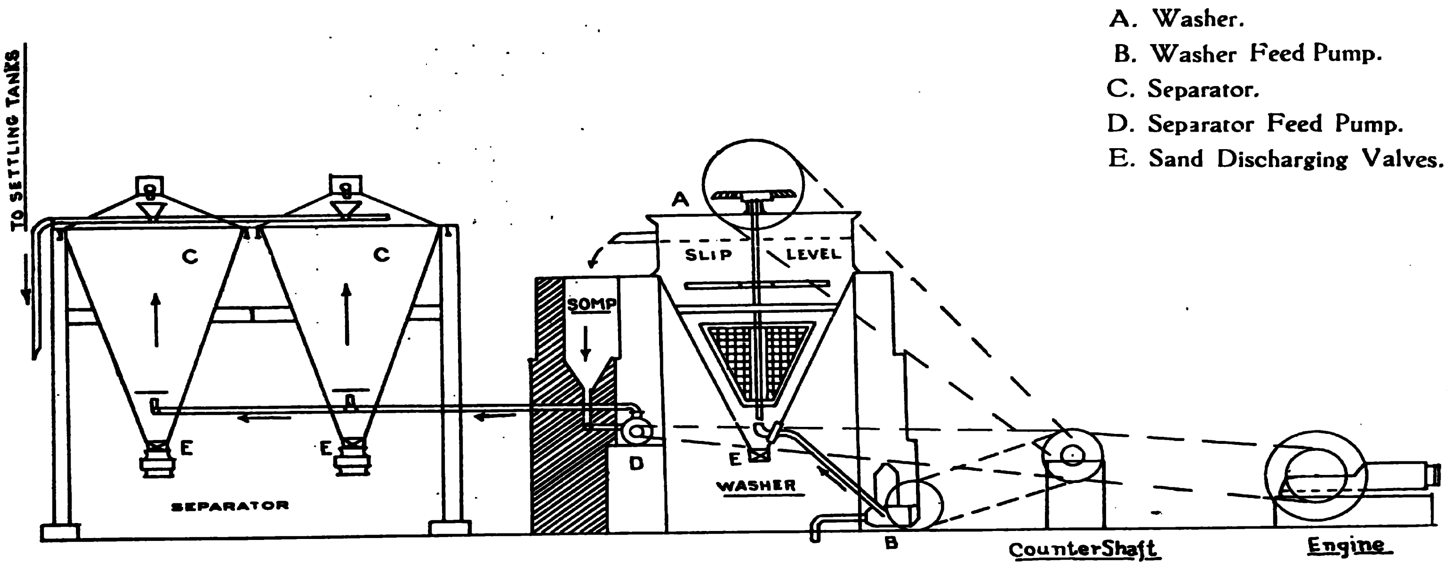
	Good Grade	Ordinary Grade
Clay	60%	40%
Gritty matter	20%	45%
Moisture	20%	15%

The above are only averages, and better and lower grades of clay are also noticed.

The Refining—The refining of clay consists of three operations. In the first place the clay is taken by tubs and dumped over into washers, where clear water is pumped up. The Kasimbazar Mines possess both mechanical and so-called hand washers. The hand washers are huge masonry circular tanks where the process of stirring up the clay in water is done by means of hand labour. Six to eight men do this work by blades and furrows attached to long handles. When the required thickness or strength of clay and water is reached, the clay water or solution is drained off by

Fig. 2.—Shows the hand washers.

means of pipes on the floatation principle and the sand is allowed to settle at the bottom of the tank. The flow of the clay is made to traverse several channels and smaller tanks or sand catchers in order to retain more of the free fine sand that has escaped from the washer and finally dropped into settling tanks. The settilng tanks hold several tons of clay. The sand which settles down in the washer requires cleaning once a week, the channels and sand catchers are attended to every day. The mechanical washer has a great advantage over the hand washers. This washing system



CHINA CLAY REFINING PLANT.

M. N. Mazumdar *del.*

The Indian Photo Engraving Co., Cal.

comprises a conical shaped mild steel tank equipped with a driving system for stirring up the clay and water (sketch attached for ready reference). Water is led by means of a forced pump from a side pipe at the bottom above the grit discharge valve and the clay is thrown in from the top. Thus the amounts of both clay and water are easily regulated. The blades attached to the driving system mix up the contents by constant agitation. The clay water overflows into a side tank or clay sump from where the clay is pumped up to the sand separators by a centrifugal pump.

Two separators are joined to the washer. These are a sort of inverted pyramid tanks fitted with watertight sand valves. The clay solution enters the separators through a spray device at a point about one-third the height of the separators, and comes out through slots at the top of the separators, finally passing through outlet pipes to the settling tanks.

Fig. 3.—Snapshot on the right shows the mechanical washers at a distance, the haulage system and the separators. The picture on the left shows the separators at close view.

The washers and the separators have certain special devices for the control of the flow of water, the clay solution, sand separation etc., which need not be specially described here. The process is so controlled that all grit is made to collect at the bottom of the separators and the clay substance only flows over to the top. The sand and gritty matters are cleaned intermittently and discharged into tubs both from the washer and the separators. It will be apparent that only fine sand comes out of the separator and the quartz and gritty substances of high dimensions are let off from the washer.

Fig. 4.—Snapshot showing settling tanks and washers.

The settling of clay in solution from the hand washers and mechanical washers is done in six square tanks and this is the second stage in the refining process. Ordnarily it takes about 12-16 hours to settle, but this time is reduced by the addition of a few pounds of aluminium sulphate into the tanks which complete the settling in about 4 hours. The execessive use of sulphate of alumina cannot however be encouraged because this is found by experience to reduce the plastic properties or the suspensibility of the clay owing perhaps to the minute trace of the sulphate which

remains in the clay and the lowering of the colloidal properties of the clay.

When the clay has settled in the tanks the water is drained off from the tanks by means of right-angled bent pipes having their shorter ends connected to the outside drain running along the tanks and the longer arms dipping into the water inside the tanks. This drained water passes to a common reservoir and can be used over again.

The settled clay at the bottom of the tanks are connected by means of pipes to a suction pump, which discharges the clay to filter presses or pressing out the water from the clay and forming it into blocks or cakes, before it goes to the drying chamber.

The final stage in the refining is the drying of the pressed cakes of clay. The clay which thus comes out of the presses still contains about 15-20% moisture.

The drying plates are constructed of $10' \times 5'$ boiler plates rivetted on to $3''$ channel iron frames to form steam-tight hollow bodies. The hollow plates about 32 in number are arranged on one level on supports in a covered shed. The cakes are placed on the plates and steam at about 10 lbs. pressure is allowed to pass inside these plates, the pressure being controlled by safety valves attached to pressure gauges. The condensed water is discharged by outlet pipes attached to the plates.

Each batch takes about 8 hours to dry completely. The dried clay is dumped down from the plates to a comented floor underneath where it is packed and despatched in gunny bags.

When weather conditions are favourable, as it undoubtedly is from January to May, the surplus stock of pressed clay is dried in the sun on a large cement platform.

As caly, dried much over 100°C, gives off its water of hydration slowly with consequent loss of its porosity and plasticity, care is necessary in drying. The steaming arrangement described above is such that the temperature cannot but be near about 100°C.

The washing efficiency of the hand washers is about 75% and that of the mechanical washer 9%. In practice about 3 tons of crude clay are required to produce 1 ton of refined clay.

The sand that comes out of the mechanical washer is over 97% pure. The loss of clay in mechanical washing system is due to the overflow of clay water which is incidental to the opening of discharge valves for cleaning. The loss in the case of hand washers is due to the sedimentation of clay in the sand at the bottom of the washers. By a second washing this sand too can be cleaned up to 97%.

It need be mentioned that in other Singbhum mines, the washing is only carried out in hand washers and drying is done in the sun. These mines do not even possess presses, but take out the settled slip from the tanks in buckets and spread out the clay in balls or lumps made by hand. The washing and drying arrangements in other clay mines in India are also extremely poor.

Those who are aware of the conditions prevalent in other countries will have to admit that Indian mines must make rapid advance in order to compete successfully with foreign manfacturers both in quality and in price. There is no import duty on clay and steamer freights from exporting ports are invariably cheaper than railway freights for transportation in India. With large scale production and better refining system the importers will always be at an advantage over indigenous productions. This applies specially to the supply of clay to the cotton mills in Bombay and Ahmedabad which are by far the largest consumers. The writer will revert to this subject later on in the course of this article.

Chemical and Physical Composition of Clays :—Pure kaolin is shown by the chemical formula $Al_2O_3.2H_2O.2SiO_2$. It is monoclinic. It has a specific gravity between 2·2-2·6. It has a hardness of 1 according to Moh's scale, lustre dull and colour white. It is considered infusible and is soluble in hot concentrated sulphuric acid.

From the commercial point of view, the only physical properties of importance are colour, feel, plasticity, suspensibility and comparative absence of free silica or gritty matters. Majority of consumers go by these physical tests and it is only the advanced few who care for the chemical analysis. However, impurities in the

clay will greatly affect the manner in which it will behave towards heat and chemicals. Traces of iron, copper and manganese beyond a certain limit will impart a dull appearance to dyed textiles. It is also known that potash, soda or oxides of iron increase the degree of fusibility, while a higher percentage of silica and alumina render it more refractory.

The cotton textiles require the best clay, the paper manufacturers the medium grade clay and the potteries the ordinary clay. Indian standard has reached the stage of successfully meeting the demands of both paper and pottery manufacturers for any grade. It has just begun to supply to the cotton mills but it is the considered opinion of the author that to maintain its position in this respect against foreign supplies the Indian manfacturer must see his way to modernise his refining system. It may be possible to make a few hundred tons of superfine clay merely by selection of the crude, but to gain a permanent market this procedure will neither be paying nor lasting. The writer will dilate uopn this at the conclusion of this article.

Physical Properties :—

Specific Gravities of Indian and Imported China Clay.

	Well-known brand of Imported Textile-Clay.	An Imported Clay Suitable for Paper and Potteries.	Kasimbazar best grade No. 1	Kasimbazar Paper grade	Another grade Singbhum Clay
Specific Gravtiy	2·21	2·35	2·34	2·43	2·42

Plasticity :—Plasticity of Indian or Singbhum clay is found to be slightly lower than the best English clay. But the best Kasimbazar clay is found to be better in this respect than common imported clay as used by paper mills.

Colour or Shade :—Colour of best grade imported clay used in cotton mills is superior in whiteness to the Singbhum clay. Singbhum clay can be made equal to best imported variety if the refining is properly handled and the selection of crude is made from large scale mining operation.

Suspensibility :—By suspensibility is meant the capacity of the clay to remain suspended in water for a reasonable length of time. On this depends the spreading power when the clay is converted into a sizing dough or applied to paper pulp as an emulsion. In this respect also Indian clay can be classed as an intermediate between the best imported clay and paper quality clay.

The author agrees with Mr. Kerridge that the suspensibility of Indian clay compared to a first class imported clay is higher for the first few minutes (about 8). In order to see whether this phenomenon will hold good if an electrolyte added to the two solutions give similar results. equal amount of clay was put in equal volumes of water, and burettes of same capacity were taken for measurement.

TABLE No. 1

(In water)

Time in minutes	Best Imported Clay	Common grade Imported Clay	Kasimbazar Clay
	Readings in Cms.		
2	6	6	
3	10	10	
4	15	15	
5	19	21	5
6	23	25	
7	25	29	
8	27	35	25
9	29	41	
10	30·5	45·5	35
13	34	47	
15	36	Settled	48

TABLE No. 2

(In water acidified with hydrochloric acid)

Time in minutes	Best Imported Clay	Common grade Imported Clay	Kasimbazar Clay
	Readings in Cms.		
2	10	12	8
4	20	25	15
6	27·5	37	27
8	32	43·5	36
10	35	46	41·5
12	37·5	—	43·5

Mr. Kerridge explains the phenomena of higher suspensibility of Indian clay in the early stages of settlement to the presence of a greater percentage of kaolinite in Indian clay. In the opinion of the author this expalnation is not conclusive and perhaps better explanation will be forthcoming by studying the colloidal properties of the two clays.

Absorption Power: Absorption power of Kasimbazar clay for water is more than lower grade imported textile clay and the paper grade. But the best quality English clay is found to be superior to Indian clay.

To see if this absorption power would follow the same order in the case of colouring matters in oils, test experiments were made with linseed and cocoanut oils. The assumption was verified. The colouring matters in the oils were most discharged by the best English clay.

Mechanical Analysis:—In order to know how clays will behave towards pyrometric tests, the following results of mechanical analysis conducted at the Hindu University will serve as a guidance. It is a well-known fact that finer the particles the greater will be the pyrochemical reactions.

According to Seger, the true clay particles are those that are under 0·01 mm in size. The results show that Indian clay contains respectively 65·1 and 69·9% of true clay substances. These results differ widely from those obtained by Mr. Kerridge who finds the English clay to contain 65·2% agianst 54·9% of the Kasimbazar clay.

	A Patharghatta Clay	B Kasimbazar Clay
Coarse particles ranging upto 0·323 mm.. diam.	0·30%	0·16%
Fine sand from 0·323 to ·040 mm.	2·00%	9·96%
Silt from 0·040 to 0·022	12·94%	10·78%
Rock dust from 0·022 to ·0010 mm.	19·98%	8·92%
Clay substance from 0·010 minimum	65·10%	69·99%
	100·32%	99·81%

Porosity and Fire Contraction of Indian Clays :—The following table gives the tests of porosity and fire contraction of Indian clays made at the Benares Hindu University. As this might be of use to Indian pottery manufacturers it is thought advisable to include the results here.

	Patharghatta Clay.		Kasimbazar Clay	
	Fire Contraction	Porosity	Fire Contraction	Porosity
1000°C	2·2%	41·70	2·0 %	40·523
1150°C	2·7%	42·00	2·423%	41·902
1170°C	3·2%	42·40	3·0 %	42·912
1190°C	4·0%	31·30	4·2 %	32·211
1230°C	8·1%	26·3	8·3 %	26·500
1290°C	9·1%	20·6	9·6 %	20·100

Behaviour towards Chemical Reagents :—As clay for its use in paper, cotton dyeing and other purposes is generally treated with water, hydrochloric acid, sulphite solution, bleaching powder and caustic soda comparative tests with these reagents were carried out. The result is tabulated below.

	Best Imported Clay	A Second grade Imported Clay.	Kasimbazar Clay.
Water	No change	Grows dull and darker	Faintly towards Yellow.
Hydrochloric Acid	Faintly Yellowish.	Marked change than in water.	A bit more Yellowish.
Bleaching Powder Solution	No change	As in water.	As in water.
Sulphite Solution	No change	Seems to improve in shade.	Seems to improve in shade.
Caustic Soda	No change	No change	No change

It appears from the treatment with hydrochloric acid that all the clays contain traces of iron. The changes with sulphite solution confirm this, although the changes are only recognised by close observation.

Chemical Analysis of Imported and Singbhum Clay.

	Imported clay				Kasimbazar clay				Another Singbhum clay
	1	2	3	4	1	2	3	4	
Silica	46·02	46·8	49·06	50·11	47·32	48·76	47·16	46·34	47·03
Alumina	39·20	38·65	36·53	35·35	38·00	38·27	36·00	36·06	35·25
Ferric Oxide	0·31	0·29	1·17	0·85	0·68	1·03	1·22	1·41	2·04
Titanium Oxide	—	—	—	—	0·12	—	0·11	0·13	0·12
Magnesia	0·17	0·24	0·36	0·51	0·28	0·55	—	—	—
Lime	0·09	0·29	0·20	0·40	0·62	1·03	0·69	0·75	0·55
Alkalies	1·18	0·30	0·17	0·57	1·12	1·69	2·98	2·62	4·00
Loss on ignition	12·82	13·50	12·17	12·21	11·86	8·67	11·84	12·39	11·46
Total	99·79	100· 0	99·66	100· 0	100· 0	100· 0	100· 0	99·70	100·45

Chemical Analysis of Imported and Singbhum Clay :—No. 1 and 2 imported clay are the best textile grades and 3 and 4 are common paper grades. No. 1 and 2 Kasimbazar represent their best grades and 3 and 4 their ocmmon paper grades. It will be noticed that the Indian qualities contain more iron and also more alkalies. Loss of ignition of Indian clay is slightly less than imported clay. Indian clay should be improved regarding its iron content. Analyses given in Mr. Kerridge's paper for English clay are apparently all paper grades, because as per author's experience English textile grade clay contains maximum 0·5% ferric oxide. In the above analysis silica represents the total silica both free and combined. It is the experienec of the author that free silica or gritty matter in Indian clay is between 1%-3%, whereas this in the imported qualities is higher.

Comparative Analysis of Kasimbazar and other Indian China Clay :—

(Results obtained at the Ceramic Department, Benares Hindu University)

	China Clay from Rajmahal	China Clay from Kasimbazar	China Clay from Patharghatta
Silica	51·21%	48·76%	47·54%
Alumina	36·97%	38·27%	37·18%
Ferric Oxide	1·18%	1·02%	1·26%
Lime	·93%	1·03%	·84%
Magnesia	·33%	·55%	1·02%
Potash	...	1·69%	...
Soda	·67%	...	0·12%
Titanium Oxide	...	...	...
Loss on ignition	8·7 %	8·6 %	12·12%
Total	100·00	100·00	100·00

Electro-Osmosis of Clay :—With a view to see how fineness and the shade of Kasimbazar clay can be improved, preliminary experiments were conducted with it by the electro-osmosis process in the laboratory of the Osmosis Company Ltd., London. The results can be summarised as under—

Semi-refined clay—The clay was mixed with water in the proportion of 900 : 1500 by weight with 6 c.c. normal sodium silicate per kilo of clay. A large proportion of clay were carried down with the residue during settlement. The clay remaining in suspension was treated by electro-osmosis process. The yields in this experiment from 437 gms. dry clay are

LOSS	Residue	202·7 gms = 46·4%	
	Clay in residue	62·7 gms = 14·4%	60·8%
YIELD	Osmosed Product	114·0 gms = 26·0%	
	Clay in Effluent	57·6 gms = 13·2%	39·2%
		437·0 gms =	100·0%

N.B. Clay in effluent is recoverable in commercial operation.

The next experiment was with crude clay (containing 15% moisture) which would presumably be used in the working of the electro-osmosing process (1000 grs. of clay equivalent to 845 grs. of dry clay) were mixed with 1200 gms. of water and 4·5 c.c. normal solution of silicate of soda as an electrolyte. After 10 minutes' settlement the suspended clay was syphoned off and treated as in the first experiment. The residue from the priliminary settlement amounted to 471 gms. = 55·7%.

This residue was found to contain—

Quartz etc.	276 gms = 32·6%
Clay substance	195 gms = 23·1%

This left 375 gms. for the electro-osmosis. Results were as under—

LOSS	Residue	166·1 gms = 44·3%	
	Clay in residue	30·7 gms = 8·2%	52·2%
YIELD	Osmosed Product	117·5 gms = 31·4%	
	Clay in Effluent	60·3 gms = 16·1%	47·5%
		374·6 gms =	100·0%

Expressing these results in terms of the original 846 gms. crude clay we have :

1st residue	Sand.	276 gms = 32·6%
	Clay matter	195 gms = 23·1%
2nd residue		166·1 gms = 19·6%
	Clay in residue	30·7 gms = 3·6%
Yield	Osmosed Product	117·5 gms = 13·8%
	Clay in Effluent	60·3 gms = 7·2%
		845·6 gms = 99·9%

From this it is apparent that the actual yield of osmosed product amounts to 21% crude clay. This yield can surely be improved upon by washing the residue and by adjusting the exact proportion of water, clay and electrolyte and also the correct voltage at which the osmosing should be carried out. In this case 50 volts. were used and the product at the anode was wet and contained 52% moisture.

The appearance of the osmosed clay was fine white and it was soft to the feel.

Electro-osmosis of Indian clay is not a commercial proposition for large scale supplies. But osmosed clay has a greater medicinal value than ordinary clay. Such a clay is sold to the medical world at a very high price. This production can be taken up with advantage by a Pharmaceutical Works in India.

A passing remark may be made that kaolin is largely used as an emulsion in medicine for human consumption. It is also administered to cattles for the treatment of certain diseases.

Conclusion :—To-day Singbhum clay is meeting all the demands of the paper mills and the pottery works in India. Minor requirements for toilet goods preapration, soaps and medicines are also fulfilled. Its progress in supplying the cotton mills is however poor. The causes working against its advance are twofold. The first is that it is not as yet as good as the best imported variety to which the cotton mills are used to for a considerable time. And as it is with everything in this country it will take a long time to overcome prejudice and bring about a change. So when the people of the country is prepared to buy a cloth turned out wholesale from Indian raw materials inspite of its being cent per cent not equal to a foreign cloth of same value, the manufac-

turers look at each other and try to steal a march over the customer and twist out from him an extra amount by making their product look apparently brighter by treatment with foreign China clay. This sort of mentality in the manufacturers of this country is deplorable.

The second reason for its lower sales in textile mills is due to the exorbitant railway freight for the transport of this commodity. Clay can be landed from Cornwall in Bombay in shiploads at about 15 shillings per ton, whereas it cannot be carried to Bombay from the mining centres at less than Rs. 20 per ton in full wagon. The production capacity of the Indian mines are much smaller than English mines and their equipments also poorer. Competition therefore naturally is keen.

If Singbhum mines owners intend to capture the textile market and successfully compete with English clay, they must bring their full resources to play.

The author makes the following observations from experience gained by him during the course of the last 14 years in large scale chemical operations and allied trade in this country and abroad which in his opinion will go to perfect the China clay industry in Singbhum.

(a) The formation of a Singbhum China Clay Syndicate or a Limited Company with a capital of Rs. 10,00,000. This Company is to produce a minimum of 15,000 tons of refined clay annually.

(b) The closing down of uneconomic mines.

(c) The adoption of modern refining system—such as the modified Dorr system. The crude clay should be first subjected to preliminary roasting at low temperature in funnel driers and subsequently air separated to discharge colouring matters and free the clay from its excessive grit contents. The pressing of wet clay to be managed by a group of continuous Rotary Vacuum Filters. The final drying of the clay to be either in vacuo or enclosed chambers by means of hot air blowers or in Rotary Driers by steam or blowers. The dried clay is to be again air separated followed by automatic weighing and bagging.

The quality of the clay likely to be obtained by this arrangement for refining will be equal in every respect to the English clay. It will have a uniform brilliant white shade, very soft to the feel and absolutely free from gritty matters.

(d) For the mining or quarrying operations hand labour is to be retained as the nature of the deposits is such as the same would not warrant the installation of excavators but better means for the disposal of the overburden from the quarry should be introduced such as carriage by travelling cranes.

A remark about the waste sand from the refining operation of Singbhum clay will be found interesting. This waste sand can be obtained over a purity of 97%. It is perfectly white and almost free from objectionable impurities, but the traces of clay make this unsuitable for glass manufacutre. Trials were made by several glass works but all failed as the presence of clay gave a dim body to the glass. It can be profitably used for building purposes and internal decorative work but owing to prevalent high transport charges to large consuming centres this outlet is also closed. Experiments were finally made with this sand at the University College of Science, Caluctta to see if this can be successfully used for the manufacture of silicate of soda. The experiment was successful.

Silicate of soda is an important widely consumed heavy chemical. It is largely consumed in soap manufacture, in hard concreting, sizing, pasteboard making and in various other purposes. The annual imports are over 2,000 tons and bulk of this is taken up by Bengal. The other raw materials required for the manufacture of the silicate of soda are salt cake or soda. As the disposal of salt cake or acid cake is a problem for all chemical manufacturer in India and as the coal for the fuel can also be obtained cheap in Bengal or Behar, the manufacture of silicate of soda either as a subsidiary to the clay industry on the spot or at a centre near about Calcutta will prove to be a useful utilisation of the waste sand obtained as a by-product from the China clay refining in Singbhum.

Nerves of Mimosa pudica

By Satyendra Nath Sen-Gupta (Calcutta).

The mysterious behaviour of many sensitive plants has engaged the attention of the Biologists all over the world. It has also made a tremendous appeal to the great Inidan plant-physiologist Sir J. C. Bose. Most of us have noticed how the sensitive plant *Mimosa pudica* droops down at the very touch of human hand. It has surprised some and puzzled many. Many scientists have probed into the question and have come forward with different explanations. Sir Jagadis also has his own theory in explanation of the peculiar phenomenon. He says that just as some sensation is created in an animal body whenever a chilly wind strikes it or any icy cold hand touches it, so also the plant *Mimosa pudica* experiences a similar sensation through its whole frail body at the slightest touch of the hand, as a result of which it bends down as if in modesty. Thus so far as the sense of touch is concerned, a parallelism is claimed to exist between an animal and a plant.

But in order to understand how a plant feels, it is necessary to know beforehand how an animal experiences the touch, communicated to its external body. The Biologists have ascertained that the animals become aware of the external touch or shock only through the agency of their internal nerves. When the excitement due to an external cause reaches the brain through definite paths or channels existing within the framework of the body, the animals become aware of the shock. The channels through which the shock or impulse travels to the brain are known as nerves. The sensation of any shock is again concomitant with the contraction of the muscles. Muscles contract as soon as the impulse due to a shock reaches them through the nerves and this contraction gives

a sure indication that the sensation has been felt. A few illustrations will clear the point.

When the tail of a lizard is cut off, the tail itself is seen to make convulsive movements. This is due to the fact that the muscles begin to contract as soon as the excitement due to the 'cut' reaches them through the nerves. A similar effect is produced when a "climbing fish" (*Anabas scandens*), bereft of its head, is seen often to jump up as soon as it is placed on a frying pan. In both these cases, contraction of muscles due to stimulation is the cause of the movement. The heads in both these cases have been severed from the bodies. Pet there is no doubt that the bodies (even in absence of brain-centre) have felt the shocks. When a pinch is given to the tip of one's finger, there follows not only a sense of pain but a simultaneous involuntary withdrawal of the hand due, no doubt, to the contraction of the muscles.

Such a nervous phenomenon may broadly be divided into three different stages :

First, the external shock.

Second, the passage of the excitement, due to the shock, through the nerves.

Third, the contraction of the muscles, when the impulse reaches them.

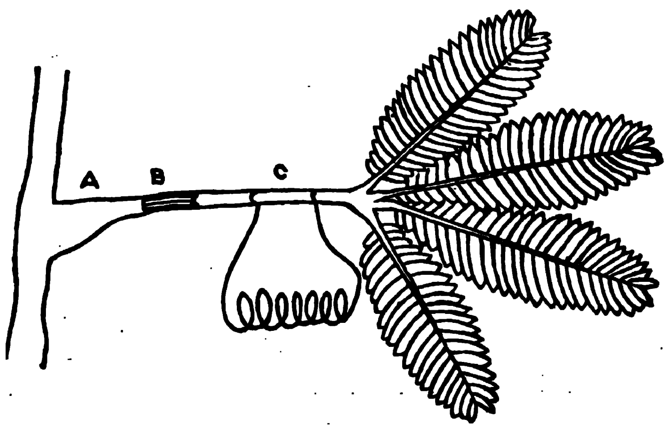


Fig. 1.—Leaf of *Mimosa pudica*.

A, pulvinus; B, cotton wool, to be soaked with ice-cold water or poison; C, electric current block.

The scientists have further discovered several special features of the nervous system known to them as *physiological blocks*. Wherever these features are found to be present one may conclude, without any mistake, that the nerves themselves are present there. Let us first of all take stock of these features.[1]

(1) The conducting power of the nerves decreases when cold is applied to them. That is to say, more than usual time is taken by the nerves, if they are cold, to communicate any particular stimulus to the muscles.

(2) If poison is applied to the nerves they lose their power of conduction. That is to say, however powerful a shock may then be given to a body, the nerves do never communicate it to the muscles and the muscles, therefore, have no cause for contraction.

(3) Similar block phenomenon occurs if instead of applying poison or making the nerves cold, an electric current is passed along a portion of the nerve through which the impulse travels. So long as the current flows the conducting power is arrested, but when the current is stopped or the block is removed, the nerve regains its original power.

These are the broad special features, which prove the existence of nerves in an animal body. We are now to investigate if the same rules equally hold good in the case of the plants.

But before we undertake this task, we must decide how we are to give shocks to a plant. If instead of being pinched, a person is stabbed with a dagger he is sure to jump up. In such a case one scarcely finds an opportunity to observe whether particular muscles of his body contracted or not, the whole framework of his body being then in an agitated condition. Let us cite another illustration. When 'pussy' is petted with slight strokes of the hand, she swells in her body and her hairs all stand on their ends under a sense of gladness. The pleasant sense of soft touch on her coat is conveyed by the nerves of her body and fills her frame with joy. But the moment you strike her hard, she will run away in

1 Bose, J. C., Plant Autographs; pp. 185-186.

fear. Similar is the case with a *Mimosa* leaf. If the shock given to it be strong it will instantaneously fall down with a twitch, nay, the whole plant will "lie low" as if in fear. In order, therefore, to conduct the experiments with a plant, the shock to be given must be properly regulated.

An electric shock given by an induction coil is the best, for it can be most conveniently regulated. But this does not mean that shocks of other kinds will be of no avail. Indeed it is not always possible for all to take recourse to electric shocks. So I would refer to some easy means which may conveniently be adopted to perform these experiments.

A prick from a very pointed needle will serve the purpose. The pointed end is inserted very slowly and lightly into the midrib of a sub-petiole of *Mimosa pudica* taking care that the leaf is not at all disturbed. The experiment may be better carried out with a pair of sharp scissors than with a needle.

By means of a pair of scissors a few leaflets towards the tip of a sub-petiole may be easily and readily cut off, and in doing so there is little chance of the leaf being bodily disturbed.

Now for the experiment. First of all a part of the petiole of a leaf of *Mimosa pudica* is to be wrapped with cotton wool. Now if a few leaflets are cut off, as stated above, by means of a pair of scissors, the purpose of giving the requisite mild shock to the plant will be served and as a result the leaflets will begin to close. The time is noted down, from a watch, when the last pair of leaflets closes (after which the pulvinule of the sub-petiole is seen to move laterally a little towards its neighbour). After some time the leaf itself will be seen to fall down suddenly. The time is noted again. It will be found that some fifteen to twenty seconds have elapsed before the impulse could reach the muscle (viz. the pulvinus). This represents the time taken by the stimulus to travel the whole length of the petiole (neglecting, of course, the *latent period* of the muscle). Sir J. C. Bose says that the sensation due to the cutting of the leaflets reaches the muscle of the plant through the nerves within the petiole, as a result of which the muscle contracts and the leaf falls down. This

reaction is similar to what is seen to occur in the case of an animal muscle-nerve preparation.

Now, if a plant really has, as we have supposed, nerves within its petioles, then it must also possess all those special features which are characteristic of the existence of nerves within an animal body.* That is to say, it must behave in the same manner to the *blocks* (viz., passage of electric current, or application of cold or poison), just as an animal does under similar circumstances.

If the time in the previous experiment has been correctly noted it will be seen that it takes generally 15 to 20 seconds for the impulse to travel from the end of the sub-petiole to the muscle of the plant (that is, from the junction of the pulvinules to the pulvinus). The excited leaf takes about 15 to 20 minutes to regain its original normal condition. In other words, the *time of recovery* of the excited leaf is 15 to 20 minutes. Now, when these timings have been carefully noted the cotton wool, wrapped round the petiole, is soaked with ice-cold water. The intense cold soon cuts into the petiole and ultimately makes the nerves within practically inert. Then again a shock is applied to the plant by cutting off a few leaflets with the scissors as before. Care is, of course, taken so that the magnitude of the shock may be the same in both the cases.

Here it is found that quite an unusual delay is being caused for the impulse to reach the muscle. The colder the petiole, the greater will be the delay and the longer will be the time. It often happens that if the petiole is kept intensely cold for a long period, the impulse would not reach the muscle at all, and consequently the leaf would not fall. If instead of ice-cold water we soak the cotton wool with some poisonous solution (e.g. *Potassium Cyanide* or *Copper Sulphate* solution), we find that the conducting power is altogether destroyed within 4 to 5 minutes' time. Similar effect is produced when electric current is made to pass. So long as the current flows, the impulse does not at all travel through the petiole

* *loc. cit.*

and cannot reach the muscle. But as soon as the current is stopped, the muscle contracts and the leaf drops down, which means that the impulse due to the shock is then carried to and reaches the muscle producing the contrary reaction.

There is another feature which, in the opinion of the Biologists, goes a great way in proving the existence of the nerves in animals. This is what is known as "*Reflex Arc*" action. When an intense stimulus impinges upon the surface of the skin of an animal, a nerve (*sensory*) conducts the ingoing impulse to the nerve-centre; the impulse is then *reflected* as an outgoing one and travels along a new path (*motor nerve*) causing contraction of the terminal muscle. This complete circuit of action is the "*Reflex Arc*" action.

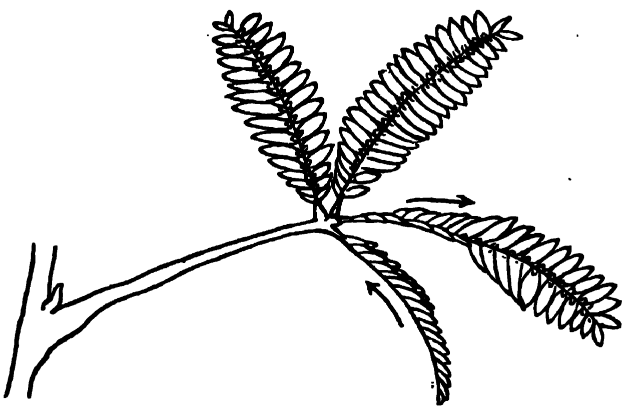


Fig. 2.—*Reflex Arc* action.
Ingoing or afferent impulse (shown by arrow pointing inwards) and outgoing or efferent impulse (shown by arrow pointing outwards).

A parallel arrangement is seen in the leaf of *Mimosa*. If, by means of a pair of scissors, three or more leaflets are cut off towards the tip of the left sub-petiole, the passage of excitation is evidenced from the gradual closure of the leaflets. When the impulse reaches the pulvinule it moves a little towards its neighbouring friend. At this stage the impulse enters the petiole and after a while the arrival of the impulse at the pulvinus is indicated by the fall of the leaf. The time taken can be determined, as before, by observing the

interval between the closure of the innermost pair of leaflets and the fall of the leaf. The impulse is then reflected back, as is clearly shown by the almost immediate gradual closing of the leaflets of the neighbouring sub-petiole in an outward direction. The interval between the fall of the leaf and the closure of the first pair of leaflets of the second sub-petiole gives the time of conduction of the outgoing impulse. It is found that the transmission-time for the ingoing impulse is on an average 20 secs., while that for the outgoing is only about 3 secs. Thus the velocity of the latter is more than six times greater than that of the former.[2] This experiment, therefore, admits of very little doubt that there is a *Reflex Arc* in the leaf of *Mimosa*.

From the facts stated above, we infer that so far as the question of response to stimulus is concerned, the same laws apply equally well to animals and plants.

But this is not all. Various experiments have been conducted with rigorous accuracy and precision at the Bose Institute, Calcutta, to prove that the plants possess nerves just as the animals do. I would mention here only a few of those interesting experiments.

It is a well-known fact that the animal-physiologists isolate the nerves of an animal body for the purpose of making all sorts of experiments with them. In the Bose Institute also similar experiments have been performed with plant nerves after isolating them from the plant body. Animal nerves when left idle for a long time become more or less inert and lose their power of conducting stimuli. We are all aware of the occasional "*tingling*" of our hands and feet when left in the same position for a considerable length of time and are not moved at all. Such hands or feet will, to a certain extent, be found dead to all external sensation. A pinch then given to them will not be felt. Such nerves, however, can be stirred into activity by the application of a strong continuous stimulation. Many, perhaps, have seen that partially paralytic persons regain their power of sensation when the benumb-

2 Bose, J. C., The Nervous Mechanism of Plants; p. 182.

ed part of the body is subjected to battery treatment. The inert plant nerves, which do not function properly, have also been examined in the same way at the Bose Institute. The changes that take place in such nerves (both of animals and plants) when subjected to a continuous stimulation, are shown in

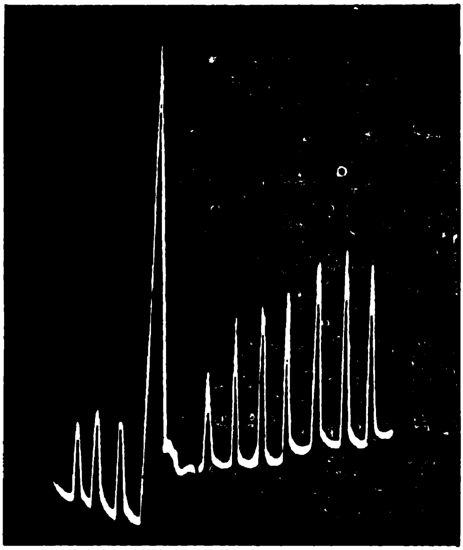


Fig. 3.—(After Bose). Isolated animal nerve: first three strokes indicate response of inert nerve and the following ones that after stimulation.

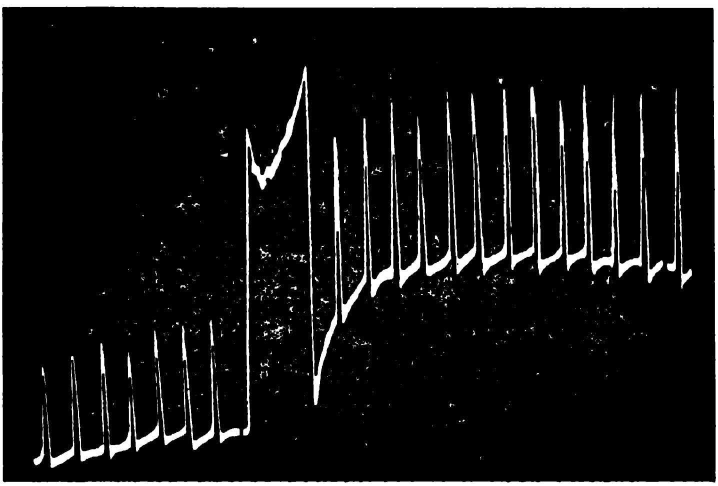


Fig. 4.—(After Bose). Isol^ted plant nerve: left-hand portion indicates response at the state inert and right-hand portion indicates response after continuous stimulation.

the diagrams (figs. 3 & 4), a comparative study of which will be quite interesting.[3]

It is an experimental fact that though the impulse due to an excitation travels in both directions through the nerves of an animal body, yet there is a difference in that it travels more easily and with greater speed in one direction than in the other. This characteristic is also found to exist in plants.[1] If with a sharp pointed needle one side of a stem of *Mimosa pudica*, carrying a few leaves, is scratched it is found that the excitatory impulse flows through the nerve within the stem; and as it reaches the pulvini, the leaves begin to fall above and below the point where the scratch has been applied, indicating that the excitation is being transmitted through the stem in both upward and downward directions. If now the time taken by the leaves to respond be noted carefully, it is found that the time of transmission of the stimulus in the downward direction is much greater than that in the opposite. That is to say, the impulse due to the scratch has travelled faster in the upward direction.

By means of selective staining and microscopic examination Sir Jagadis has succeeded in investigating the internal history and minute structural details of the conducting strands. He has discovered two distinct nervous layers (external and internal), which, so far as their properties of conducting and responding to stimuli are concerned, bear a close resemblance to the animal nerves.

3 Bose, J. C., Plant Autographs; pp. 195-197.

4 Bose, J. C., The Nervous Mechanism of Plants; p. 3 & p. 49.

Alchemy—Medieval and Modern

By Hirendra Nath Datta (Calcutta).

There is a wise saying current in this country that *occasion* makes even the voiceless vocal and imparts to the lame agility of limbs. Not having made a special study of science, my rule is to avoid dabbling in scientific topics. But the auspicious occasion of Sir Prafulla Chandra Ray's Septuagenary has induced me to make an exception. And for the purpose of his Commemoration Volume what subject can be more appropriate than Alchemy,—which (in the words of a chemical authority), in its clumsy crucibles and alembics painfully sought (in the medieval age) to change lead into gold, and incidentally founded our modern science of Chemistry?

Medieval Alchemy

When western science was young, that is in the 18th and the first half of the 19th century, it was naturally arrogant and far too self-conscious—unware that '*Modern* science appears to be re-discovering some of the discoveries of *ancient* science which were lost sight of and forgotten' (Sir Oliver Lodge). In his bumptious cock-sureness* the western scientist invariably heaped ridicule on the laborious effort of the alchemist in his laboratory to manufacture the Philospher's Stone (*Lapis Philosophorum* or Sparsha Mani, as we name it in this country)—'that perfect and incorruptible substance or *Noble Tincture* which could purge all baser metals of their dross and turn them to pure gold'—regarding

* I am old enough to remember a time when some of the spokesmen of Science (never indeed the greatest), displayed a cock-sureness that was curiously out of keeping with the spirit of to-day.—Sir Alfred Ewing, F. R. S. in his Presidential address (1932) to the British Association.

the practitioners of the Hermitic Art as no better than crass ignoramuses and their Magnum Opus ('Great Work') as so much wasted labour.

It will be out of place to dilate here on the *modus operandi* of the alchemist which, as it has come down to us, is usually veiled in far-fetched allegories, designed to convey the secrets only to the elect but concealing them from the uninitiated—and is clothed in symbolical language of deliberate obscurity. But we know this much that for the "great work" the alchemist made use of the three "elements",—sulphur, salt and mercury, the last (which he called the unseizable mercury the radical Moyst, the primitive or elementary water) being the most important. The three ingredients, being then enclosed in the Athanor (vessel), with various solvents peculiar to the different alchemistic recipes, have to be subjected to a gentle fire (the Incendium Amoris). Then the "great work" begins. But the three "elements" have to be forced into the proper combination in order that the Azoth may be formed. The mixture has to pass through three successive stages. The first stage is called "Putrefaction" when it takes on a black colour. When that is passed, whiteness appears, the stage of Luna (silver). The alchemist, when he has found Luna, is not content but tosses it back into the crucible in order that he may complete the "great work" and transmute it into Philosophic Gold, whose colour is red. Gold in the alchemist's view is the perfect metal —the crowned King or Sol, and when in the final stage 'the marriage of Luna and Sol' has taken place, then only the *Magnum Opus* is completed and the Philosopher's Stone forged. Thus the art of the alchemist consisted in bringing forth the latent "goldness" which lies obscure in the baser metals.

Whether any alchemist ever succeeded in realising his dream of transmuting the baser metals into gold may be questioned, but, as later researches have proved, his root idea that one element is susceptible of transmutation into another was not in the least *unscientific;* and in the middle of the 19th century, after science had found its feet, we find the great Faraday recording his judgment as: "To decompose the metals, then to reform them, to

change them from one to the other and to realise the once absurd notion of transmutation are the problems now given to chemists for solution. Let none start at the difficult task and think the means far beyond him: everything may be gained by energy and perseverence." In the eighties of the same century, Madame Blavatsky hazarded the bold prophesy that 'the old Alchemy would reappear as the new Chemistry'.

In the new Alchemy of the 20th century, this prophesy, as we shall see, is on the point of verification.

The Indivisible (?) Atom

Chemical science, as we know, is mainly concerned with the question of the composition of the material universe, and its conclusion is or rather was until a few decades ago, that notwithstanding its manifold multiplicity, the material universe is made up, in the ultimate analysis, of 70 odd elements. Take a drop of water. If it be divided and subdivided, say into a million parts, we get what is called a molecule; should that molecule be broken up, we shall get two atoms of hydrogen and one atom of oxygen. Or take a lump of gold. It may be divided and subdivided until we arrive at a gold molecule and ultimately at the atoms composing that molecule. In the case of the drop of water, we were concerned with a compound; here we are dealing with a simple substance or "element." Each element then—gold, silver, mercury, sulphur, hydrogen, oxygen, nitrogen etc.—is composed of atoms and some scientists have had the hardihood to assert that 'the maximum number of atoms in our visible universe is represented by the figure 6 followed by ninety one ciphers,' an atom being the minutest part into which matter is divisible*.

How minute is an atom? A cubic inch of space (according

* That these minute corpuscles can build up gigantic bodies such as the earth, the planets, the sun and stars is astonishing—like most other things in the Universe when we dive down into them. But yet it seems an undoubted fact for which the evidence is exceedingly strong.—Lodge.

to Dolbear) contains the number represented by 125 followed by 21 ciphers. Hydrogen, we know, is the lightest element and the size of a hydrogen atom has been calculated to be less than 1/1,50,000,000th part of an inch. And its weight? 'It weighs a million million million times less than a minute visible speck, such as a granule of lycopodium, which is about as small as can be weighed on a very delicate chemical balance' (Lodge). Take a molecule of albumen. Its size is said to be 1/5,000,000 of an inch and as one thousand atoms go to the composition of a single molecule of albumen, the size of this atom must be 1/5,000,000,000 of an inch.

For a long period, chemists thought that the atoms were permanent bodies, indivisible and indestructible. So late as 1894 Dolbear wrote 'No atom is destroyed, nor its individual property changed in any way. Atoms do not decay but remain as types of permanency through all imaginable changes.' In saying this, modern science merely carried on the old Greek tradition, from which the word "atom" was derived, which literally means 'a particle of matter so small that it cannot be cut or divided (a = not and temien = to cut).' That was also the idea of the Vaisesika Philosophers—the ancient physicists of India, who spoke of the atoms or "Anus" as being eternal (Nitya) and taught that the material universe was composed of four kinds of "permanent" atoms—the earthy, the watery, the fiery and the airy, and that these atoms progressing downwards became monatomic, diatomic tetratomic etc. (*Anu Dwanu Trasarenu* etc.). (This was disputed in the Sankhya and the Vedanta Systems. But that is another story). Against this view of the indivisibility of the atom, Madame Blavatsky, who claimed to be in touch with ancient science, entered her caveat, asserting that 'it was on the infinite divisibility of the atom that the whole science of occultism was built.' But orthodox science looked askance, entrenched in its rigid immobility.

The Atom breaks up

The first inroad, so far as a mere layman can make out, into the indestructibility of the atom was made by what are called the

"Cathode Rays". These rays, as every schoolboy now knows, are produced when a current of electricity is sent through a glass tube, out of which all but the merest fraction of air has been exhausted by a powerful airpump. The current of electricity enters the tube by one wire called the positive pole and leaves it by the other wire termed the negative or "Cathode" pole, and when the current is passing through the tube a bright glow of light is seen in the neighbourhood of this Cathode. To this light is given the name "Cathode Rays". When the scientists carefully examined these rays, they were driven to the conclusion that the action of the electric current had been to split up into infinitesimal fragments the particles of air left in the tube and that these Cathode Rays really consisted of streams of these infinitely minute fragments, which were found highly charged with (negative) electricity. Glass, as is well known, is one of the very densest of substances,—the fine-grained matter of which it is made up being so closely locked together that it is practically impervious and impenetrable. Liquids will pass through a coarse-grained material like a flower pot, for example, but not through glass; even air does not penetrate it, nor ordinary electricity. But in the case of the Cathode Rays, so minute are the particles which compose them, that they pass through the glass as if it were a sieve. The pores of the tube are too small to let the air atoms through but these Cathode Rays pass through quite easily, because they are minuter than the atom. Thus science had to admit that it was possible to subdivide the atom and dealing with these Cathode Rays, Prof. J. J. Thompson affirmed that they must be one thousand times smaller than an atom of hydrogen gas.

Then came the discovery of radium by Madame Curie. The behaviour of this strange element attracted considerable notice. It was found, among other things, that radium gave off "emanations." These were collected in glass flasks, and after having examined them, scientists declared that they had no doubt that radium atoms were breaking up before their very eyes. Now came loud protestations from sundry Professors, who vied with each other in disowning the 'atom.' 'An atom is an atom no longer—not a

single indivisible unit but a congeries of moving and warring bodies' (Lodge). 'Physicists have found that the chemical atoms can be broken up into bodies called electrons' (Rutherford). 'We have no reason to suppose that the so-called atoms are not dissociable at high temperature' (Lockyar). 'The atom of a gas is composed of smaller corpuscles' (J. J. Thompson). In their new-born zeal, a few (it seems) protested too much—Mr. R. A. Fesenden, an eminent American mathematical physicist, estimating that an atom of hydrogen comprised about one thousand corpuscles and an atom of mercury contained about two hundred thousand corpuscles. Anybody it was conceded on all hands that the atom was not, as theretofore believed, the fundamental unit but 'a little world in itself of complicated and delicate structure.'

Protyle and Prakriti

By this time Sir William Crookes had published his provoking paper on the "Genesis of the Elements" suggesting, what the fact was, that 'not one of the elements of Chemistry really deserved that name' (Secret Doctrine, vol. 1, 584) and Lord Kelvin had, formulated his epoch-making Vortex-Atom Theory, reminding one of the *puranic* fable of the charming of the Milky Ocean (the sea of homogenous root-matter) with *Mandara* as the stable axis and the positive *Devas* and the negative *Asuras* tugging the serpent *Vasaki* in opposite directions so as to produce spiral motion in that primeval sea. Thus scientists came to suspect what occultism had always taught viz., that 'the recognised chemical elements were in fact modifications of a single material element', which came to be called the primordial element or the meta-atom.

Each of the known elements—oxygen and iron and gold etc., must, as they now saw, be really built up of a number of these meta-atoms and that the difference between the atom of oxygen and the atom of iron depended upon the structure of the atom and not upon the material of which it was made.

Thus what had been called an atom was found to be a composite body, a compound—not an *element* and it was now said that there was but one matter and that all chemical elements were

but modifications, aggregations, of this one ultimate matter—"a complicated collection of units, themselves similar" (Rucker).*

To put the idea clearly before the mind, one writer compared the primordial atom to a brick. With the same sort of bricks, he said, you might build a great variety of houses—a temple, a palace, a townhall etc. 'Each sort of house, to follow out that illustration, might be regarded as a chemical element and instead of these chemical elements, it was this 'primordial atom' that was the material of which the world was made, and the first business at its making was to make the chemical elements.'

Sir William Crookes had already laid the foundation for all this by his "Protyle"—the root base of the chemical elements. Earlier still, the author of "World-Life" had declared—"It is the dream of science that all the recognised chemical elements will one day be found to be modifications of a single material element." This had also been asseverated by Madame Blavatsky in her *Secret Doctrine*: 'There is only one fundamental element in the system. That one element undergoes numberless aggregations, dissociations and modifications, resulting in all the innumerable compound bodies.'

May I pause for just one moment over this homogenous Protyle of Crookes? To me it has a familiar ring and reminds me of *Prakriti*, the rootless root (*Amulam Mulam*) of the Sankhyas—which was in a state of 'differential equilibrium' that was broken up by the cyclic impulse at the end of *Pràlaya* and underwent sevenfold primary differentiation in the seven planes of the Cosmos, giving rise to the seven *tatwas—Adi, Anupadaka, Akasa, Vayu, Tejas, Apas, and Kshiti*—the *Mahat, Ahankara* and the five *Tanmatras* of Kapila, which are spoken of as the seven *Prakriti-Vikritis* of the afore-mentioned primary undifferentiated equilibrated *Prakriti*. Thus there are really not one but seven Protyles and it was the last, the Protyle of the physical plane, which Crookes' Chemistry sought and found and this primordial

* It appears more than possible that all the elements—oxygen, hydroben, copper, tin and iodine for example—are but allotrophic modifications of one kind of matter, the "Protyle" of Professor Crookes.—Sir William Ramsay in November 1903.

stuff it was that at the dawn of evolution in the present cycle separated off into atoms and aggregated into molecules.

The structure of the Atom

In recent years there has been much investigation and shall I say speculation as to the "architecture of the Atom", that is, its nature and composition. As might be expected, the experts do not all speak with one voice. How can they? Has it not been said and said truly—*Nasai Munir Yasya Matan na bhinnarm*? But the generally accepted view, which is mainly based on the researches of Rutherford and Bohr, may briefly be formulated thus: (in this I am condensing two remarkably lucid articles by Sir Oliver Lodge and Dr. A. S. Russel respectively and shall, whenever possible, make use of their language, so as not to fall into any unconscious misrepresentation). An atom, according to this view, is built up on the general pattern of a solar system, that is to say, it consists of bodies which are much like the sun and planets on a very minute scale (Lodge). First of all there is a group of protons in the centre which may be taken to represent the sun and outside it and at some distance from it, a regular series of electrons revolving round it, either singly or in rings like the planets.

All atoms, we are assured, are built up on one single plan. What is that plan? There is the nucleus—the massive positive proton near the centre (like the central sun in a solar system) and revolving electrons, playing the part of planets round that sun. The number of revolving electrons vary from one to ninetytwo. They are mobile units of negative electricity with a mass that is negligibly minute (its diameter being about 37½ times the hundred-million-millionth of a centimetre) and a velocity which is almost gigantic, varying from about 50,000 to 186,000 miles per second. The proton also moves with incredible velocity but it differs from the electron in possessing mass and in being positive and not negative electricity. (The proton, though no bigger than the electron, weighs as much as 1830 electrons. In other words, a proton weighs just about the same as an atom of hydrogen, but it is in bulk a million million times smaller). The number of protons

in the atom's nucleus varies for different atoms, from one to two hundred and forty. As to the group of protons in the centre, 'half of them are welded together by a compact and interleaved assemblage of electrons, which are also able to hold on the other half of the protons, as part of the compact group' (Lodge).

As already stated, the nucleus of the atom contains negative as well as positive electricity and as these units are exactly equivalent, the actual positive charge which the nucleus bears is not the number of its protons but that number minus the number of nuclear electrons. Take an atom of gold. The nucleus at its centre contains 197 protons and 118 electrons, so that its net positive charge is 79. It has been found that the number of net positive charges in the nucleus of an atom of any kind exactly corresponds to the number of planetary electrons therein* and this is its most characteristic property and it is called the atomic number. Hydrogen, the lightest element known, has in its nucleus a positive charge of one, it has one planetary electron. The nucleus of helium, which is the second lightest element, has a net positive charge of two, it has two planetary electrons. Lithium is the third lightest. Its nucleus has a net positive charge of three, it has three planetary electrons. And so on until we arrive at uranium, which is the heaviest of elements; its nucleus has a net positive charge of 92 and it has 92 planetary electrons.

There are then 92 chemical elements in nature (each with its own atom)no more and no less, and each element has its own atomic number. The atomic number of some of the more familiar elements may be given below: hydrogen 1, helium 2, lithium 3, carbon 6, nitrogen 7, oxygen 8, sodium 11, chlorine 17, iron 26, gold 79, mercury 80, lead 82, radium 88, uranium 92. No element but gold has the number 79. If it were changed, whether spontaneously or artificially to 78 or 80 or any other number, it would cease to be gold and become another element. (What is here said of gold is true of every other element).

* The number of un-neutralised protons at the centre and the number of planetary or revolving electrons in any given atom, in its normal state, must be the same. Many or few, there must be the same number of each.—Lodge.

Here then is the *modus* of transmutation of one element into another. If we can alter the net positive charge in the nucleus of an element, then that element will inevitably change into another. Take mercury which has 80 net positive charges in its nucleus. 80 positive charges may become 79 in two ways, by losing a positive charge or by gaining a negative one. The former possibility, so far as one can judge, is most unlikely. But suppose a negative charge is by some means incorporated into the nucleus of a mercury atom, that atom will in the most matter-of-fact way be transformed into gold. Thus the *theory* of the thing is plain enough. But has such transformation been ever effected in *practice*?

Transmutation of Elements

Now, if we watch the behaviour of what are called the radio-active elements (uranium, radium etc.), which are also the heaviest of the chemical elements, we may observe the transformation of one chemical element into another, taking place *spontaneously* in nature. A radio-active element is, we know, 'one which possesses, in addition to the properties of a normal element, the power of emitting spontaneously α- or β- particies.' As another authority has put it: 'Raio-active elements explode as a canon explodes, firing off a shot with vehemence, at a speed of several thousand miles an hour.' Be it noted that this action is absolutely spontaneous and beyond the control of human agency in any way. No chemical combination with other elements, no physical manipulation, such as enormous temperatrue or pressure, seems to be able to affect the process at all. Speaking of this radio-activity (what Lodge characterises as the tumbling down process) Dr. A. S. Russel says: "A definite fraction of the total number of atoms comprising the radio-element breaks up every second. The consequence of the expulsion of either an α- or a β- particle is that the residual atom is completely different from that from which it results, or what is the same thing, from an atom that has not broken up. A radio-element consequently contains always at least two kinds of atoms —those that have broken up and those that have not. The un-

changed atoms comprise the parent element: the residual atoms comprise the product. The product is perfectly distinct from its parent in physical and chemical properties and can easily be separated from it by the ordinary methods of analytical chemistry. If now the product happens like its parent to be radio-active, a certain fraction of it will disintegrate per second to form a third substance and this body, if radio-active, will produce a fourth, the fourth a fifth and so on, till a substance is reached which has not the power of disintegrating, when the series of elements abruptly ends. Such a series is called a disintegration series and three of these are at present known. In a disintegration series, each element but the last is the parent of the one that follows and except the first, the product of the one that precedes. The elements that head the three series are the rare elements uranium, thorium and actinium; the element that terminates each series is the common element lead."*

All this is very interesting but it hardly carries any appeal for the 'practical man'; for, of what use is the production of a common element like lead from rare substances like uranium or radium? It would (proceeds Dr. Russel) be excellent, if the process could be reversed. But the process cannot be reversed. It proceeds always from heavier to lighter atoms owing to the fact that an α-particle having a mass of 4 is expelled at each step. But the atoms of gold and platinum and even mercury are lighter than those of lead, the descending order of atomic mass being lead, mercury, gold and platinum, so that if radio-activity did not cease with lead, these rare elements would be spontaneously produced from it. But again

* In this connection it is useful to remind us of certain experiments conducted by Sir William Ramsay in the early days with the emanation which radium is constantly giving off, which Ramsay collected in tiny flasks. "He found that after it had been collected for a couple of days, its spectrum—which previously was entirely unlike any yet studied—began to display the typical yellow line of helium, the gas first known and christened by its constant presence in the Sun. In four or five days, the helium line grew brighter and in another week the spectrum of helium was positively blazing in the hermetically sealed tubes that had been filled with the pure emanations or gaseous output of radium.* * * In other words, one element had been literally seen to change into another of quite different nature, under the eyes of the experimenters".

the 'practical man' is baulked. The natural process stops abruptly at lead.

But can artifice succeed where nature fails? That is exactly the task which the alchemist had set before himself. We know that scientists have succeeded in the artificial disintegration of atoms of a few of the lighter elements. This was successfully carried out by Sir Ernest Rutherford and his colleagues at Cambridge about 1912, who started with the theory that if we could strike an atom like a target by a projectile then it might be disrupted, and this is what actually occurred. Rutherford used as projectiles the violently flying α particles emitted by the radio-element radium C. When he directed these projectiles on to or rather through the atoms of some of the lighter elements (boron, nitrogen, fluorine, sodium, aluminium and phosphorus) thousands of them hit nothing, but occasionally they did hit the nucleus, with the result that the atom so hit was disintegrated and some of its odd fragments were flung out with great velocity and he got a few violently ejected atoms of hydrogen. Here then was the artificial transmutation of one light element into another.

But can we do it with the heavier elements—lead and silver and mercury, for instance?

Now, from time to time there have not been wanting 'excursions and alarms' in this field, but so far they have failed to secure the assent of the strait-jacket scientist. Some years ago the news-sheets were full of Professor Emmens, a skilled American metallurgist who claimed that 'in the reduction of silver the molecules are so subdivided as to differ so materially from the metal that they must be regarded as a new substance, parent apparently of both gold and silver' and fruther claimed that 'this new metallic substance can be aggregated into molecules of greater density than silver and corresponding to gold in colour and weight.'

A similar claim was put forward later by M. Jollivet Castlelot, the President of the Alchemical Society of France, who boldly published his recipe to the world, instead of keeping it a secret. The recipe which is set out below will be found quite straight-forward and the ingredients simple.

'One hundred and twentyfive parts of chemically pure silver are melted in a clean crucible. To this is added seven parts of yellow orpiment (arsenic trisulphide) and three parts of antimony sulphide. This is fused together for about four hours at 1,000 degrees Centigrade and produces a yellowish coloured ingot. The latter is again melted, and ten parts of orpiment and five parts of antimony are again added, little by little, to the pot. It is kept at the same temperature as before for a further four hours.

'Then comes the last process of fluxing the ingot. Ten parts of salpetre and the same amounts of sal-ammoniac and borax mixed with a paste of scraped white soap are added to the crucible. This claims the molten metal, which again changes colour from gold to white. It is then poured out and cooled.

'The operators claim that the mass now consists of silver alloyed with a small proportion of gold. Analysis and assay estimates indicate that the gold content is about one quarter per cent of the silver employed.'

These claims, however, left official science cold and the claimants themselves were regarded as self-deluded egoists, if not imposters. Later still came the experiments of Dr. Adolf Miethe of the Technical University in Charlottenburg, Berlin, who published a detailed bulletin as to how he had succeeded in making gold out of mercury. This created much stir in scientific circles. So it is worth while to summarise the process used by the Doctor. 'He passed (I am quoting Dr. Russel's description) a high tension discharge through pure mercury vapour for many hours continuously, and discovered that in certain circumstances the mercury at the end was contaminated by a small quantity of gold. This amount was very small, rarely exceeding one part in hundred million parts of mercury, but by using a large quantity of mercury and prolonging the current for many days, the experimenter obtained sufficient gold not merely to give the characteristic behaviour of this element towards chemical reagents but even to show its colour and streak. * * The high-tension electric discharge which he used consisted of swiftly moving electrons. In his apparatus these would collide with atoms of mercury. A very small proportion of the electrons would

penetrate the outer layers of the atoms and be directed on to the nuclei. The majority of them would not do this, partly because the nucleus was a very small target easily missed and partly because the energy necessary to reach the nucleus might have been lost in encountering obstacles. But as soon as the electron had penetrated the protecting barriers, it would fall into the nucleus unless, for some reason, the usual behaviour shown by positive charges of attracting negative charges did not hold here. The moment the electron is captured by the nucleus of mercury that necleus becomes a nucleus of gold.' Dr. Miethe's achievement has met with serious challenge in certain quarters where it has been asserted that the so-called pure mercury vapour used by him was not pure after all, but was already tainted with a very faint trace of gold.

Whatever that might be, it is important to bear in mind that transmutation of this artificial kind is possible, unless indeed the present views of atomic structure are radically wrong. As we have seen, the fundamental property of an element is the excess of positive charges of electricity over negative in the nuclei of the atoms composing the element. This number for mercury, as we have seen, is 80, that for gold is 79. If by any means an electron (a negative charge) can be successfully conveyed to and absorbed by the nucleus of a mercury atom, that electron would transform the atom of mercury into an atom of gold. No doubt the process is very very difficult. As Sir Oliver Lodge has observed—'Atoms are exceedingly porous, just as porous as a solar system, so that a projectile going through them is quite unlikely to hit anything. But every now and then it may, and sooner or later it must, on the doctrine of chances. It may go through ten thousand atoms without hitting anything. But if ten thousand projectiles were loosened through the solar system at such speed that gravitation had no appreciable effect, one of them at least might hit the sun and then something would happen.' What is that something? There is a smash and the sun breaks up: that is to say, that atom is disintegrated, not spontaneously (as in radio-activity) but by the explosion of a shell or the impact of a violent projectile, and we get violently ejected atoms of another kind. As another writer has put

it—"By knocking a piece off the sun or adding a piece to it, the substance changes entirely."

As I have said, the process is the reverse of easy. But we may take heart from Faraday's brave words already quoted, "Everything may be gained by energy and perseverence." Moreover is it not presumptuous to assume that the methods hitherto made use of by modern science, which have presumably failed. are the *only* ones available to human ingenuity and intuition? It may well be that the medieval alchemists of Europe and for the matter of that, the ancient alchemists of India and China were in possession of other and better methods which modern science will someday rediscover and then succeed in this final task of transmutation.

Spiritual Alchemy

Raising Alchemy to the spiritual level, as the Hermetic Philosophers (who call themselves the spiritual alchemists) have done, may we not regard the whole legend as an allegory of transmutation of the "natural" into the "supernatural" man? For when he, who was of the earth earthly, ascends to the perfect state, becomes perfect as "the Father in Heaven is perfect", is not his nature utterly transmuted into a "new form"? This is more than hinted at by Sir Thomas Browne in his Religio Medici and is expressly declared by the German mystic Jacob Boehme. 'Would you fain find the Noble Stone?' he asks, 'It is in a simple form and has the power of the whole Deity in it'. At the same time Boehme gives a solemn warning that if you be not a *Magus* and worthy, you shall ever remain blind.

From this viewpoint, Man is 'the true laboratory of the Hermetic Art'. He is constituted, as Saint Paul has told us, by a body, a soul and the spirit—the sulphur, salt and mercury of the alchemist. 'Sulphur is man's earthly nature, seasoned with intellectual salt, and mercury is spirit in its most mystic sense' (Underhill on Mysticism)—the human-Divine spark, the Divine fragment (to use the language of the Gita). This mystic mercury,

'the scrap of Reality' within Man, has to transmute the sulphur and salt of his senses and his mind until the lower metal, his personality, is profoundly affected and 'suffers a sea-change, into something rich and strange' until the 'natural man' is transmuted to Divine Humanity which *is* the 'spiritual gold' of the alchemist. This process is called "Purgation" in Mysticism and the Mystic has rightly pointed out that there can be no transmutation without fire—"no cross, no crown." When this fire has done its office, and the "Noble Stone" has been fashioned, the great work is finished. For by this process of spiritual Alchemy, a new Saviour has come to birth, the true *Lapis Philosophorum,* which, as the spiritual alchemists point out, is a tinging stone and is not only itself gold but, what is more, imparts its *goldness* to the baser metals brought within its sphere of influence. In other words He not only saves *himself* but can and does save *others.*

Using another kind of symbology, the spiritual alchemists speak of the whole process of transmutation as "the hunting of the Green Lion"—the wild intractable Personality, full of vim and vitality but 'wanting maturities' and so rightly called "green". This beast has to be tracked and caught after a long chase and then you have to decapitate him. That is to say, you have to so treat your personality that it becomes *practically* dead. But not utterly—for as soon as you have cut off this lion's head, he mysteriously grows wings wherewith to fly to *Sal,* the Perfect or Divine and is then transformed into the Red Dragon, which is an apt symbol of Deified Man—the *Hiranya-Shasru, Hiranya-Kesha Apranakhat Suvarna* (golden to the finger tips) of the Upanisads. Thus the *Magnum Opus* is finished.